EXHIBIT 38

Exhibit C

Evaluation of Environmental Contaminants and Health Risks in the Metropolitan Complex

Expert Report

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Nov. 6, 2020

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1 Purpose and Basis

I have examined materials relevant to understanding potential exposures and adverse health risks in the case: Maxus Metropolitan, LLC. versus Travelers Property Casualty Company of America, Case No. 20-cv-00095-FJG (US District Court – Missouri). My review of documents and my evaluation focus on the following: the extent of smoke penetration into the Maxus Metropolitan apartment building complex (Metropolitan) as a result of the structure fire on September 27, 2018 fire; the significance and distribution of fire-related combustion residues determined by sampling and analysis by Maxus; the adequacy of sampling protocols, analyses and interpretations related to combustion residues and mold; whether detected or remaining fire-related combustion residues were likely to cause adverse health effects among building occupants; and whether full remediation or reconstruction of Phases 1-4 buildings was warranted as a result of the risks of adverse health effects associated with fire-related combustion residues determined from the sampling and related analyses. My evaluation is based on the data, reports, and other references cited in this report, including the text, footnotes and list of documents reviewed.

My qualifications are described in the curriculum vitae provided. I am an environmental health scientist and engineer with research and teaching interests in exposure science, risk and health impact assessment, and epidemiology applied to occupational, community and environmental settings. I received a BS in environmental science from Rutgers University, and Masters and PhD in Civil & Environmental Engineering from the Massachusetts Institute of Technology. Previously I taught and conducted research in Massachusetts, Texas, Finland, Austria, Portugal, and elsewhere. Since 1989 I have been at the University of Michigan where I am Professor of Environmental Health Sciences, Professor of Global Public Health, and Professor of Civil and Environmental Engineering. I addition, I am Honorary Professor, Department of Occupational and Environmental Health at the Medical School University of KwaZulu-Natal, Durban, South Africa. At Michigan, I am Center Director of the *National Institute of Occupation Safety and Health supported T42 University of Michigan (UM) Center for Occupational Health and Safety Engineering*, and the *National Institute of Environmental Health Sciences (NIEHS) supported T32 Environmental Toxicology and Epidemiology Program*, and I lead the leader of the Exposure Assessment Core of the NIEHS-supported P30 *Michigan Center on Lifestage Environmental Exposures and Disease*. My research and teaching emphases ambient and indoor air quality, exposure and risk assessment, environmental epidemiology, and air quality modeling. I routinely procure highly competitive federal and other grants and complete research addressing air quality, housing quality, and other environmental health topics. My laboratory specializes in exposure measurements and exposure assessment, including trace organic measurements in biological and environmental samples, and my group conducts a wide range of laboratory and field studies, as well as environmental modeling and statistical analyses. I am committed to conducting impactful research, to developing training and research programs that promote knowledge and capacity in the occupational and environmental health sciences including training at UM, elsewhere in the US, and abroad, and to community engaged research and policy-relevant work. I have published over 220 peer-reviewed journal articles, hundreds of abstracts and reports, of which many are peer-reviewed. I have made numerous scientific presentations on environmental health topics, and served on city, state and national panels on environmental health topics.

In the past 5 years I have given been deposed and given testimony in a case before the Alberta (Canada) Energy Regulator in Applications 1842705, 1851246 and 1851250, Proceeding ID 346, Balshaw Oil Corp. In addition, I been retained in the following cases: Tatjana Blotkevic, Ilya Peysin and Yakov Yarmove v. City of Chicago, No. 2016-CH-02292; Sierra Club v. Union Electric Company d/b/a/ Ameren Missouri, Civil Action No. 14-cv-00408-AGF; Robert and Kerry Ellen Hart vs. Mountain West Farm Bureau Mutual Insurance Company; U.S. District Court Case No. CV 19-08-M-DWM. In the latter three cases, I have not testified or been deposed. During this period, I have also given testimony in public hearings related to permitting and rule-making in environmental matters before the Michigan Department of Environment, Great Lakes and Energy, and before the U.S. Environmental Protection Agency. I am being compensated for this work at a rate of $425 per hour.

2 Chronology

The Metropolitan Apartments are a residential complex constructed of three wood frame slab-on-grade buildings with a parking garage, located in Birmingham, Alabama. The three buildings are referred to as the Phase 1-3 building or the "donut building", the Phase 4-5 building that wraps around the parking structure, and the stand alone Phase 6 building. The complex is bounded by 6th Avenue to the north, 7th Avenue to the south, 30th Street to the east, and 29th Street to the west. Commercial and light industrial businesses are located along 6th Avenue and to the north, with service and retail establishments along 7th Avenue and to the west. An architectural plan showing the building "phases" is shown in Figure 1. Figure 2 shows the floor plan and unit numbers. Other floors have similar numbering of units other than the first digit indicating the level.

On the night of September 27, 2018, at 0:37, the local fire department was dispatched to 2900 7th Ave South to respond to a two alarm fire that occurred in the detached (except for connecting bridge) southeast, stand-alone building (referenced as the Phase 6 building), which sustained a catastrophic fire and burned completely. The building burned very quickly, on the order of 2 hours.[1] The fire was extinguished by 6:00 am.[2] The earlier phase of the fire, well before daybreak, was the most intense based on the incident report and television news coverage.[3] Much of the firefighting equipment was cleared by approximately 8:00 in the morning, although some equipment remained on site until 14:30.[4]

At the time of the fire, approximately 17 units on the 4th floor were occupied, in the Phase 1-3 Buildings, based on the Rent Charges/Payments Ledger. Phases 4 and5 were unfinished. , e

On June 11, 2019, Maxus counsel stated their intention to evict all tenants from the Metropolitan, and the building complex was vacated by June 17, 2019 (263 days after the fire). At this time, 96 units in Phase 1-3 Buildings were occupied.

In October, 2019, Bear Claw Construction Management, LLC, initiated the removal of sheet rock from Phase 1-3 buildings, essentially deconstructing the building to framing.

Maxus contracted with Forensic Building Science, Inc. (FBS) to conduct inspections and collect environmental samples at the Metropolitan. A total of 15 visits from Jan. 9, 2019 through August 27, 2020 conducted for this purpose were identified. Most of these visits occurred in 2020.

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1 Security video taken at or near 2930 7th Ave South throughout the fire, immediately south of the Phase 6 building. This camera points approximately north and directly at the Phase 6 building.

2 Birmingham Real-Time News. Massive 2-alarm fire destroys Lakeview apartments, law office; Birmingham firefighter hurt. https://www.al.com/news/birmingham/2018/09/massive_2-alarm_blaze_destroys.html

3 TV Channel 13, WVTM, DRONE VIDEO: Massive fire destroys 4-story apartment building in Birmingham's Lakeview Districthttps://www.wvtm13.com/article/drone-video-massive-fire-destroys-4story-apartment-building-in-birminghams-lakeview-district/23498813

4 Birmingham Fire & Rescue Service Incident Report 2018-0050328

Figure 1. Architectural plan with corresponding area classifications. From Irmiter exhibit 47.

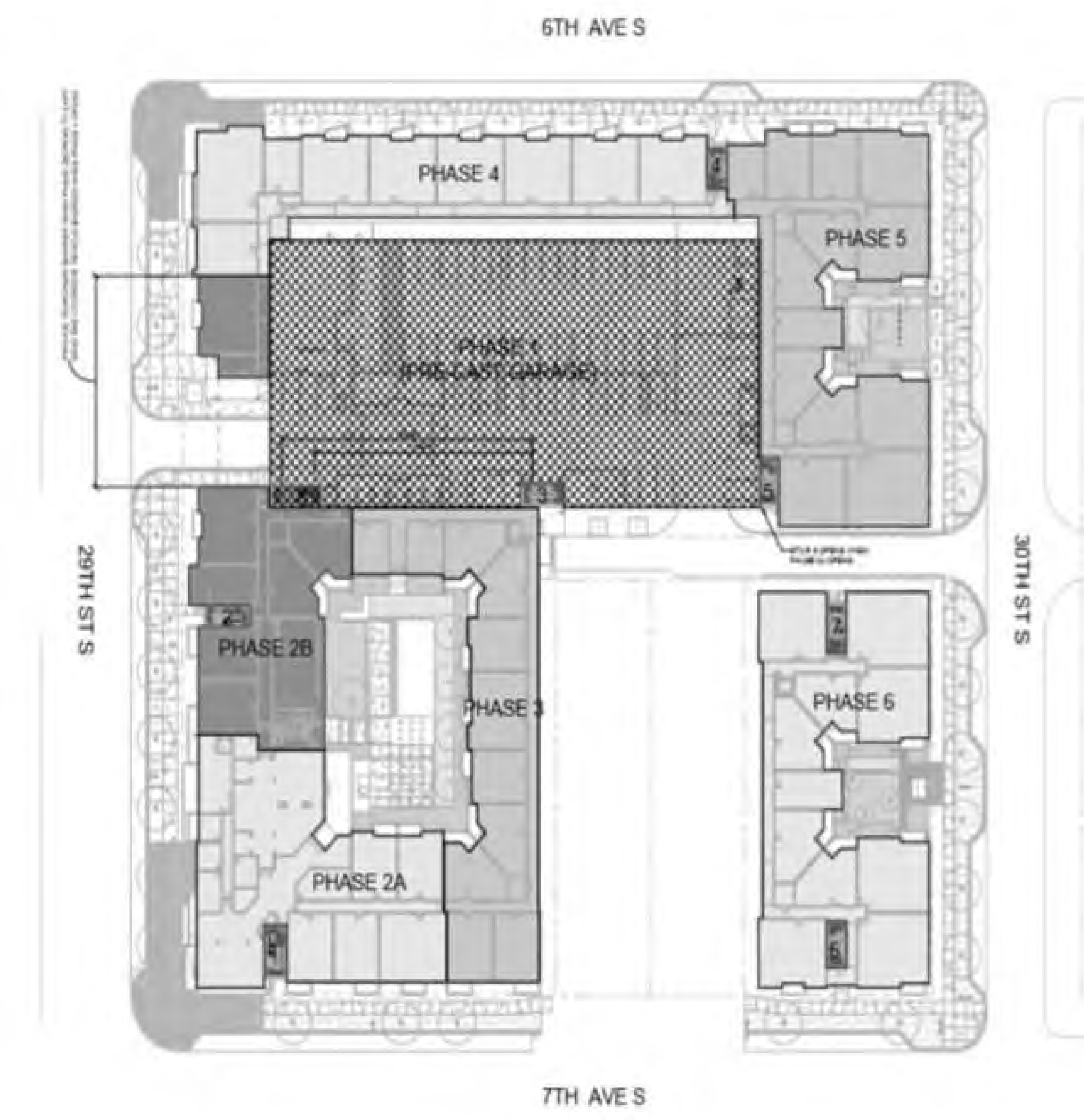

Figure 2. Floor plan for 2nd floor of the Metropolitan. From R. Schroeder.

3 Impact of fire-related emissions on indoor environmental quality and health

Structure fires and their smoke plumes can affect indoor environments and indoor environmental quality (IEQ) through several mechanisms and in several phases. The fire at the Phase 6 structure was external to the Phase 1-5 buildings. This section provides background on the emissions, transport and fate of fire-related pollutants, called *combustion residues* in this report, which might occur from the emissions of the Phase 6 structure fire that migrated into the Phase 1-5 buildings.[5] Additional background regarding smoke transport and infiltration in Section 4.

Fire-related pollutants can be emitted and found in a building through one or several of mechanisms or phases defined and discussed below with reference to the Metropolitan Phase 6 building fire.

3.1 Direct exposure

In the initial or active phase of the fire, emissions of gaseous and particulate pollutants from a fire may enter occupied portions and interstitial spaces of the building (e.g., attic, wall cavities), a result of normal *air exchange, air infiltration*, and pollutant *penetration* through the building envelope, which can cause direct exposure to building inhabitants if present. Following the fire, airborne pollutant concentrations in the building will decline rapidly as normal air change rates flush out airborne pollutants, typically in a few hours. Other pollutant loss mechanisms, e.g., settling, deposition and reaction, also occur and are discussed below. Pollutants of most concern for direct exposure include volatile organic compounds (VOCs), gases (e.g., carbon monoxide), and particulate matter. Direct exposure to fire-related contaminants is normally avoided by evacuation of building residents. Direct exposure to fire-related contaminants is not an issue at the Metropolitan.

3.2 Settling and deposition

Particulate and some gaseous/vapor phase pollutants from a fire may *settle or deposit* on building surfaces, both exposed surfaces and hidden surfaces and in building cavities. In wild land fires, exterior surfaces of a structure generally sustain the most direct impact of wildfire residues;[6] similar deposition and settling processes will occur for nearby buildings exposed to smoke from structure fires. A fraction of particulate and some gaseous/vapor phase pollutants may penetrate the building envelope or enter the HVAC system. Some pollutants may *absorb* into porous materials (e.g., foam, fabrics, carpets, filters, insulation). Surface cleaning of exposed surfaces, material removal, and other remediation activities are expected to reduce or eliminate much of this contamination. The presence of settled or deposited char, soot and ash on interior building surfaces and building cavities is the rationale for many of statements regarding the condition of the Metropolitan (Sections 4 and 5).

3.3 Off-gassing

Settled, deposited and/or absorbed solid-phase pollutants may later produce gas-phase emissions, known as *off-gassing* or the *sink/source* effect. Emissions from off-gassing can include parent compounds or reaction products. Both will be emitted in the vapor phase, and these emissions may later condense or absorb and coagulate to

5 There appears to be some confusion in the record regarding the origin and identification of combustion residues. While the fire was a structure fire, any fire-related combustion residues found in the Phase 1 – 5 buildings resulted from the entry or penetration of particles through the building envelope and into the building; these residues were not generated internally in Phase 1-5 buildings. In this regard, combustion residues are similar to a wild land fire: pollutants were emitted from the nearby source; released into the atmosphere; underwent cooling and physical and chemical changes; and then exposed nearby buildings to "aged" combustion products, including soot, ash and char. In the case of the Metropolitan, however, these emissions arose from a structure fire.

6 AIHA, 2018 Daniel Baxter, Alice Delia, Susan Evans, Brad Kovar. AIHA Technical Guide For Wildfire Impact Assessments. A Guide for the Occupational and Environmental Health and Safety Professional. American Industrial Hygiene Association, April 2018.

become particulate-bound and re-settle or re-deposit on other surfaces. Sink/source processes can apply to some VOCs and semi-volatile organic compounds (SVOCs). The significance of sink/source processes depends on the pollutant, substrate, and environmental conditions. Generally, off gassing rates and indoor concentrations decline over time as the pollutant is depleted or degraded; higher ventilation rates and higher temperatures will increase the rate of decline, and rapid declines are expected for VOCs and many SVOCs including polycyclic aromatic hydrocarbons (PAHs) (Section 7.3.3). Months or potentially years after a contamination event, sink/source effects may be significant only for certain compounds, e.g., very low volatility and persistent chemicals, and only under certain conditions, e.g., disturbances (Section 7.3) .

3.4 Entrainment

The physical disturbance of previously settled and deposited pollutants that have accumulated on surfaces or dust may be *entrained* and *re-entrained* into air. Disturbances can include vibration, movement, sweeping, and high velocity air flows (as in an air duct). Cleaning of surfaces will greatly minimize the potential for entrainment of fire-related combustion residues. In building cavities, disturbances that cause entrainment of previously deposited or settled combustion residues are very unlikely with the exception of building repairs on specific surfaces or aggressive sampling techniques (Section 7.3.2). Outdoors, burnt materials and soil contamination immediately after the fire can contain friable materials that can be entrained by winds; this material would normally be removed or covered soon after a fire, and thus these emissions would be short-lived.

3.5 Heat-related emissions

Heating of building materials and furnishings may produce emissions that affect indoor pollutant levels. High and prolonged temperatures can cause or increase emissions by: increasing off-gassing rates of components present in building materials and furnishings (e.g., from oils and resins in wood and construction materials); initiating reactions forming airborne emissions (e.g., charring and burning); and deteriorating or destroying the integrity of materials that subsequently leak and/or release contaminants (e.g., melting of plastics and caulks and bursting of capacitors in electronics). There is minimal if any documentation in occupied spaces in Phases 1-3 or elsewhere of heat-related emissions or related concerns.

3.6 Remediation

Remediation activities, which can include physical disturbances (e.g., sweeping and vacuuming) and use of chemicals (e.g., cleaners, deodorants, sterilizers, disinfectants), may affect the indoor environment. Typically, remediation activities produce the highest emissions and concentrations during the remediation. The likelihood of significant emissions or impacts due to typical remediation practices conducted months or years earlier is typically minimal.

3.7 Summary

This section has reviewed mechanisms pertinent to fire-related emissions and chemical exposures in buildings that can cause health risks. A primary concern at the Metropolitan is that the contamination of building surfaces and materials by fire-related combustion residues will cause adverse health effects among occupants due to carcinogenic substances such as PAHs. As detailed below, no evidence supports this conjecture.

4 Smoke transport and infiltration

Outdoor smoke from a structure fire or other source can enter a building if <u>two</u> conditions are present: (1) the *building exterior must be exposed to smok*e *and high concentrations of fire-related pollutants*, particularly at air entry locations and for prolonged periods; and (2) *air infiltration and particle penetration of smoke and fire-related pollutants enter through the building envelope and into the building*.[7] These conditions – the *exposure* and *completed pathway* – depend on the fire and building configuration, local and prevailing meteorology, pressure differences, pollutant type, and other factors.

4.1 Winds during the fire and plume transport

Meteorological data measured at two airports near the Metropolitan are summarized in Table 1. Two airports are near the Metropolitan: the Birmingham Airport is 5.5 NNE of the Metropolitan, and the Bessemer Airport is 15.9 miles SSW. These airports span the Metropolitan location, as shown in Figure 3. Data from the two airports substantially agree during the fire period and thus are representative.

From midnight to 5:59 am on 27 September 2018, winds were light or classified as calm, (no wind detected); the average wind speed was 1.7 to 2.1 mph (depending on the airport), and the wind direction was from the SSE and S. From 5:59 am to 12:00 pm, wind speed increased slightly (average of 4.3 to 6.9 mph) and the direction remained from the SSE and S. These are very light to light winds. *Sheltering* effects from nearby buildings would tend to reduce the wind speed in Birmingham from the measurements at the airports. <u>Overall, meteorological conditions at the time of the fire and immediately after were calm, very light or light winds from the SSE and S</u>.

Given the calm, very light and light winds during the fire, <u>the fire would produce a heated and buoyant plume that would rise vertically and be transported upward and primarily to the north and the north-northwest</u>. Figure 4 shows the orientation of the Metropolitan building complex. The general plume direction and vertical rise of the plume is corroborated by the placement of the firefighting equipment on the 7th Avenue South midblock location[8] and videos taken from appropriate perspectives.[9] Based on prevailing winds, the plume direction would direct the plume away from Phase 1-3. Phase 5 and a portion of Phase 4 are in the downwind direction of the plume; however, the vertical movement of the plume, called *updraft* or *plume rise*, is the dominant transport mechanism given the calm, very light and light winds during the fire and the sheltered location of the Metropolitan.

Wind speeds immediately after the fire are too low to entrain material into the air.

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[7] *Infiltration* normally refers to air leakage through unintentional openings in the exterior envelope of a building, driven by wind, indoor-outdoor temperature difference and equipment operation. *Particle penetration* refers to the entry of particles into a building via leaks in the building enclosure or envelope. These terms have been used interchangeably by FBS but they are not the same.

[8] Birmingham Fire & Rescue Service, Incident Report, 2018-0050328. The incident commander designated the 29th Street location as the alpha side of the structure, and reported heavy black smoke on alpha (front: 29th Street) and bravo (left: 6th Ave). No smoke was reported on the delta side (right side: 30th Street).

[9] Video footage from a drone provides a good perspective to show the plume rise, as captured by WTVM, Channel 13, "Drone video of Lakeview fire" at https://www.wvtm13.com/article/birmingham-firefighters-battling-massive-commercial-fire-in-lakeview-district/23483089, accessed Nov. 1, 2020.

Table 1. Meteorological observations at Birmingham and Bessemer airports for Sept. 27, 2018 from 12:00 am to 2:30 pm, as available.[10] Horizontal lines separate observations into midnight to 5:59 am and 6:00 am to 11:59 periods. Horizontal lines show averaging periods. Averages shown at bottom of table.

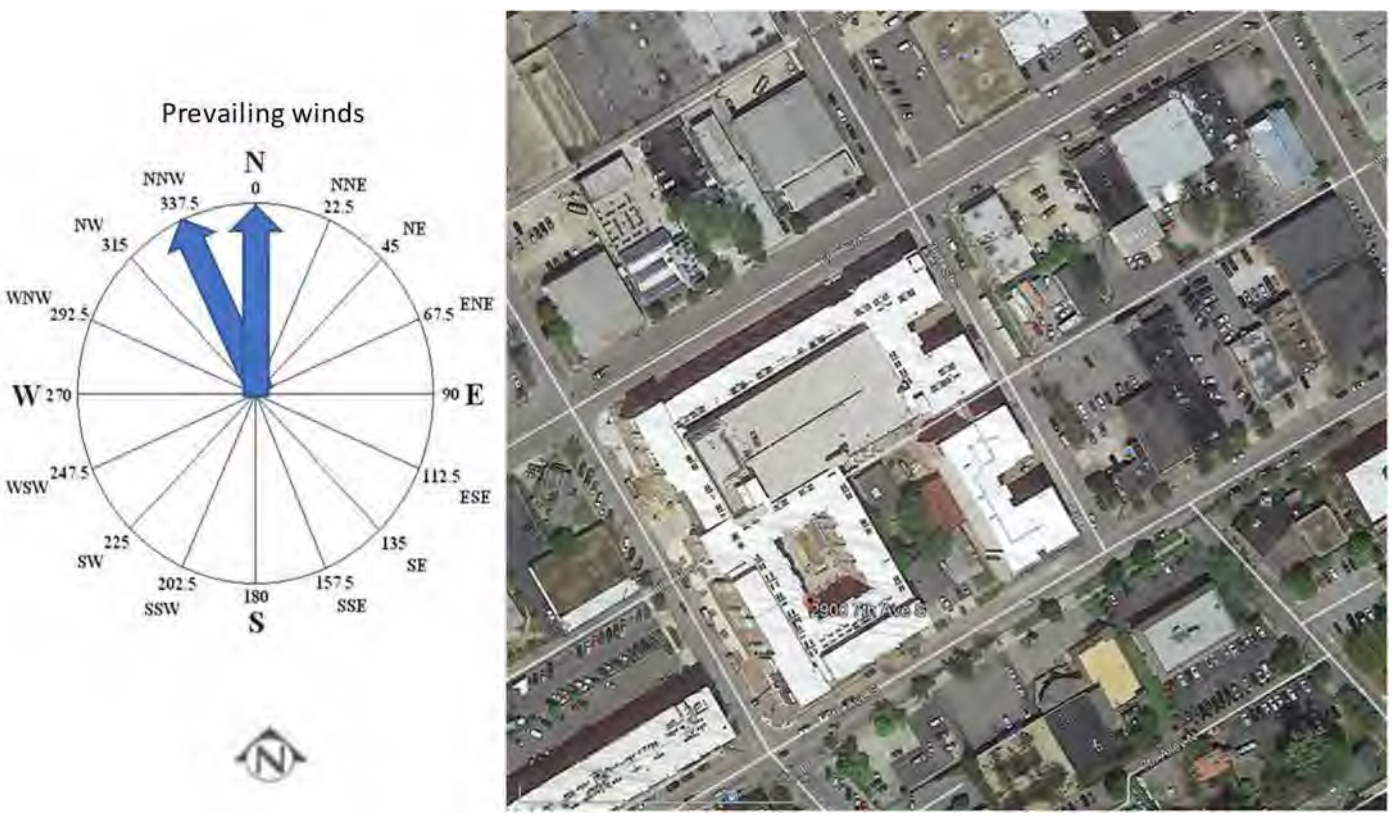
Birmingham Airport (1)										Birmingham Airport (2)				Bessemer Airport			
Time	Temperature	Dew Point	Humidity	Wind	Wind Speed	Wind Gust	Pressure	Precip.	Condition	Time	Wind Dir (o)	Condition	Wind speed (mph)	Time	Wind Dir (o)	Condition	Wind speed (mph)
12:38 AM	71 F	69 F	93 %	CALM	0 mph	0 mph	29.34 in	0.0 in	Cloudy	0:38:00		Calm	0.0	0:56:00		Calm	0.0
12:53 AM	72 F	70 F	93 %	CALM	0 mph	0 mph	29.34 in	0.0 in	Cloudy	0:51:00		Calm	0.0	1:56:00		Calm	0.0
1:53 AM	72 F	70 F	93 %	CALM	0 mph	0 mph	29.34 in	0.0 in	Cloudy	0:53:00			3.4	2:24:00		Calm	0.0
2:53 AM	72 F	70 F	93 %	SSE	3 mph	0 mph	29.34 in	0.0 in	Cloudy	0:59:00		Calm	0.0	2:35:00	220		3.4
3:38 AM	71 F	70 F	96 %	SSE	3 mph	0 mph	29.33 in	0.0 in	Cloudy	1:53:00				2:46:00	240		3.4
3:53 AM	71 F	70 F	96 %	SSE	3 mph	0 mph	29.33 in	0.0 in	Cloudy	2:53:00		Calm	0.0	2:50:00		Calm	0.0
4:35 AM	71 F	70 F	96 %	SSE	5 mph	0 mph	29.33 in	0.0 in	Cloudy	3:38:00	160		3.4	2:56:00		Calm	0.0
4:53 AM	71 F	71 F	100 %	S	3 mph	0 mph	29.33 in	0.0 in	Cloudy	3:51:00	150		3.4	3:27:00		Calm	0.0
5:04 AM	71 F	71 F	100 %	CALM	0 mph	0 mph	29.34 in	0.0 in	Cloudy	3:53:00	150		3.4	3:47:00		Calm	0.0
5:53 AM	72 F	70 F	93 %	CALM	0 mph	0 mph	29.34 in	0.0 in	Cloudy	4:35:00	160		3.4	3:56:00		Calm	0.0
6:53 AM	72 F	70 F	93 %	SE	3 mph	0 mph	29.33 in	0.0 in	Cloudy	4:53:00	150		4.7	4:33:00	150		4.7
7:53 AM	72 F	71 F	97 %	CALM	0 mph	0 mph	29.34 in	0.0 in	Cloudy	5:04:00	170		3.4	4:37:00	150		3.4
8:53 AM	73 F	71 F	93 %	S	7 mph	0 mph	29.34 in	0.0 in	Cloudy	5:53:00		Calm	0.0	4:52:00	160		3.4
9:00 AM	73 F	71 F	93 %	S	6 mph	0 mph	29.34 in	0.0 in	Light Rain	6:53:00		Calm	0.0	4:56:00		Calm	0.0
9:09 AM	73 F	71 F	93 %	S	7 mph	0 mph	29.35 in	0.0 in	Cloudy	7:53:00	140		3.4	5:09:00	160		3.4
9:43 AM	74 F	72 F	93 %	S	6 mph	0 mph	29.35 in	0.1 in	Light Rain	8:51:00		Calm	0.0	5:56:00	150		5.8
9:53 AM	74 F	72 F	93 %	S	7 mph	0 mph	29.35 in	0.1 in	Light Rain	8:53:00	180		6.9	6:14:00	140		4.7
10:00 AM	74 F	71 F	91 %	S	7 mph	0 mph	29.35 in	0.0 in	Cloudy	9:00:00	180		6.9	6:50:00	160		4.7
10:09 AM	74 F	72 F	93 %	S	9 mph	0 mph	29.35 in	0.0 in	Cloudy	9:09:00	180		5.8	6:56:00	150		3.4
10:42 AM	75 F	72 F	90 %	S	10 mph	0 mph	29.34 in	0.0 in	Cloudy	9:43:00	180		6.9	7:56:00	160		5.8
10:53 AM	75 F	72 F	90 %	SSW	8 mph	0 mph	29.34 in	0.0 in	Mostly Cloudy	9:53:00	180		5.8	8:56:00	180		4.7
10:56 AM	76 F	73 F	91 %	SSW	7 mph	0 mph	29.34 in	0.0 in	Mostly Cloudy	10:00:00	170		6.9	9:56:00	180		5.8
11:53 AM	79 F	72 F	79 %	SSW	13 mph	17 mph	29.33 in	0.0 in	Cloudy	10:09:00	180		6.9	10:33:00	200		6.9
12:53 PM	77 F	72 F	84 %	SW	9 mph	0 mph	29.31 in	0.0 in	Light Rain	10:42:00	180		9.2	10:56:00	210		6.9
1:23 PM	77 F	73 F	88 %	W	7 mph	0 mph	29.29 in	0.0 in	Rain	10:53:00	190		10.3	11:56:00			4.7
1:31 PM	75 F	73 F	94 %	WNW	8 mph	0 mph	29.28 in	0.1 in	Heavy Rain	10:56:00	200		8.1	12:08:00			6.9
1:41 PM	74 F	73 F	97 %	WNW	9 mph	0 mph	29.28 in	0.4 in	Rain	11:53:00	200		6.9	12:56:00	180		8.1
1:53 PM	76 F	74 F	94 %	VAR	5 mph	0 mph	29.27 in	0.4 in	Cloudy	12:53:00	200		12.8	13:56:00	190		9.2
2:01 PM	76 F	72 F	87 %	SSW	3 mph	0 mph	29.27 in	0.0 in	Mostly Cloudy	13:23:00	220		9.2	14:21:00	210		8.1
2:35 PM	76 F	73 F	91 %	CALM	0 mph	0 mph	29.27 in	0.0 in	Heavy Rain	13:31:00	260		6.9	14:51:00	240		6.9
Aveage from 0:00 to 5:59 am					1.7						157		2.1		176		1.7
Average from 6:00 to 11:59 am					6.9						180		6.0		173		5.3

[10] (1) From Weather underground https://www.wunderground.com/history/daily/us/al/birmingham/KBHM/date/2018-9-27

(2) From National Center for Environmental Information, https://www.ncei.noaa.gov/access/search/data-search/global-hourly?stations=72050799999&stations=72228013876 Wind speed converted to mph.

Figure 3. Map showing locations of airports. The Metropolitan and fire site was located in central Birmingham, between the two airports. Modified from NOAA.

Figure 4. Left: Compass rose showing downwind direction of prevailing S and SSE winds during the fire period; Right: Google Earth photo of the Metropolitan complex, dated 4/2018, with the correct orientation with respect to the compass rose.



4.1.1 Plume dispersion

The dispersion of smoke and plumes is well understood, and many types of pollution sources are competently modeled to estimate exposures that may result.[11] In brief, the flow, randomness and turbulence of atmosphere wind field produces a degree of mixing and dispersion, with additional small scale *micrometeorological* affects due to flow over and around obstacles (like buildings) and from other effects. This means that while the dominant or average direction of a plume from a fire can be determined from the prevailing wind field, there is always a degree of vertical and lateral spread of the plume due to gusts, eddies and turbulent dispersion. In the case of the Metropolitan, the dominant direction was vertical and to the N and NNW. Dispersion would occur that would broaden or spread the plume, with the resultant direction likely to include portions of the upper floors of Phases 4 and 5. As shown in Section 7, this is consistent with the areas where most fire-related combustion residues were identified with high likelihood.

In certain cases, especially large and open fires can produce changes (perturbations) of the wind field. One such effect is the formation of a *convergence zone*. In general, heated and buoyant gases above the fire combustion zone cause the plume to ascend and *updraft*. In certain large forest fires, plume-driven fires (occurring with light winds) can draw in air near the ground surface, forming a short-lived and localized convergence zone. The radial inbound air flows in such zones have velocities that are much reduced from updraft velocities.[12] While unlikely, if such a convergence zone formed at the Metropolitan fire site, then in buildings other than the burning Phase 6 structure, building sides facing the fire (*near side*) would experience a slight drop in air pressure that could reduce infiltration, while building sides opposite the fire (*far side*) would experience a slight increase in pressure that could increase infiltration, however, the building far side would be expected to have considerably less exposure to the smoke plume. In any event, the ground level air velocities from such a hypothetical convergence zone resulting from the structure fire would be too low to cause significant wind-induced infiltration and particle penetration through the building envelope. Overall, there is no evidence for prolonged and significant convergence zone or other fire-induced perturbation of the wind field that would be likely to significantly increase infiltration and particle penetration into the Phase 1-3 and Phase 4-5 buildings.[13]

4.1.2 Incorrect interpretation of meteorology conditions

Contrary and misleading meteorological information was presented by FBS, who reported the maximum wind speed as 25 mph, the direction from the northwest, and winds as "sustained".[14] A brief but intense thunderstorm

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[11] Much of my work focuses on atmospheric dispersion modeling of pollutants, including stationary and mobile sources in order to understand exposures and the potential for health effects. Please see CV.

[12] There are numerous field campaigns and modeling studies regarding air flows pertaining to forest fires. For example:

Lareau, Neil P., Craig B. Clements. The Mean and Turbulent Properties of a Wildfire Convective Plume, *Journal of Applied Meteorology and Climatology,* 56, 8, pp. 2289-2299, 2017

Charland, AM, C. B. Clements. Kinematic structure of a wildland fire plume observed by Doppler lidar. *Journal of Geophysical Research: Atmospheres*, 118, 3200–3212, 2013.

[13] If winds were high and "sustained" as erroneously stated by FBS, then the discussion fire-induced convergence zones and wind field modification would not apply and thus be irrelevant. In contrast, in the Expert Report on p. 21, FBS asserts: "In my opinion, winds generated by this fire, not winds in the surrounding area, created the perfect condition for distribution of microscopic fire particulate and combustion byproducts that are harmful. These winds and the heat from the fire created the mechanism for the building pressurization to occur."

[14] FBS, Fire Damage Report for The Metropolitan, 2700 7th Avenue South, Birmingham, AL 35233. June 5, 2019. (Exhibit 47). This report (and the expert report) makes a number of speculative, undocumented, sometimes contrary and sometimes irrelevant speculations, including the following:

occurred at the Birmingham airport from about 2:40 pm to 3:15 pm September 27, 2018, which produced a very brief period of high winds and a brief reversal of the prevailing direction. However, this has no bearing during the night-time fire period when winds were calm, very light, or light and from the SSE and S.

FBS inappropriately quoted an interview of a scientist formerly at NCAR discussing *coupled fire atmosphere dynamics* that can result in perturbation of the wind field purported to apply to the Metropolitan fire.[15] The cited paper from this scientist, from 1996,[16] uses numerical modeling to simulate line-type forest fires under primarily light winds in a modeling application mainly intended to test several hypotheses under simplified and hypothetical scenarios. While an interesting and relatively early paper on coupled fire-atmosphere dynamics, this paper is largely irrelevant to understanding wind patterns related to the Metropolitan fire: it simulates line fires from 420 to 1500 m long (0.25 mile to nearly a mile) of eucalyptus trees that are uniformly distributed across a landscape, not a structure fire in a heterogeneous urban setting; there are substantial differences in burn rates, geometries and other factors between the simulated line fire and the actual structure fire that do not scale down; important elements of the model are considered crude (e.g., fire model, radiation model); the model does not include effects of the forest canopy on drag, and thus does not simulate the effects of nearby buildings on sheltering and drag; the model spatial resolution (finest was 40 m) could not represent features of a structure fire like the Phase 6 fire (the building dimension, approximately 55 x 26 m, would be represented with a single pixel) and extrapolations are fallacious; and the paper's simulations have not been validated with real field data.

The FBS expert report made additional speculations and misleading statements regarding infiltration and local conditions.[17]

On p. 3: "In our opinion, based on the type of construction of the building, the methods used to fight the fire, and the sustained winds the night of the fire, smoke, soot, and particulate matter penetrated all aspects of the unfinished buildings and much of the finished building areas. Emphasis added.

Text on p. 4 notes: "As part of our investigation FBS conducted weather research into wind speeds and wind direction during the event. According to that research sustained high winds blowing in a northwest direction occurred. In our opinion, this could have resulted in winds carrying soot, water, and particulates onto, and throughout, all remaining structures interiors by way of the open bypasses throughout the complex and HVAC equipment which was operating in the occupied spaces." Emphasis added.

On p. 20 of the FBS Expert Report, FBS asserts both "positive and negative pressure" in the building.

On p. 55: "The analysis by Carlson is consistent with the spread of combustion byproducts from this fire and a building that underwent a sudden and dramatic pressurization caused by the heat and winds generated by the fire."

On p. 14 and 15, it is asserted that the fire caused "fire whirls" and "weather modifications".

15 FBS, 2020, ibid. p. 15 describes an indirect reference to Clark, see below, and asserts: "In my opinion, this fire was large enough to effectively create its own weather pattern in the form of circulating high winds forcing Phases 1-4 to pressurize and become engulfed in smoke. While the fire was not large enough to create a "meteorological event" like some forest fires and volcanoes it did extend well above the structure" …. "the fire was large enough to create its own weather pattern."

16 Clark, Terry L.; Mary Ann Jenkins; Janice Coen; David Packham A Coupled Atmosphere Fire Model: Convective Feedback on Fire-Line Dynamics, *Journal of Applied Meteorology*, 35, 6 1996, pp. 875-901.

17 FBS, Expert Report, Oct. 5, 2020. For example, on p. 12: "turbulent winds created by the fire and the heat from the fire caused the pressurization of the building to change and pushed black smoke, and combustion byproducts from the fire into Phases 1-5." Emphasis added.

4.2 Infiltration of smoke and fire-related pollutants

The second necessary condition for smoke entry is the entry of outside air into the building. Modern building like the Metropolitan have engineered systems that limit air and moisture entry, e.g., the Metropolitan used the ZIP System sheathing designed to form a tight and continuous barrier, on top of oriented strand board (OSB), which is also highly impermeable. Air and smoke from a fire and other ambient air pollutants can enter a building by crossing through the building envelope, including these barriers, driven by several mechanisms: *mechanical air change* due to fans drawing in outside air; *natural ventilation* through open windows and doors; and *infiltration* though gaps and leaks in the building envelope. The housing units at the Metropolitan did not utilize HVAC systems with mechanical air exchange. "Infiltration" has been claimed as the means by which fire-related combustion residues entered Phase 1-5 buildings.

Infiltration will only occur if there is a *pressure difference* across the building envelope, specifically, higher pressure outdoors and lower pressure indoors. A pressure difference can arise from several factors: (1) effects of winds; (2) indoor-outdoor temperature differences, called the *stack effect*; and (3) if certain multiple fan heating, ventilation and air conditioning (HVAC) systems are operating but incorrectly balanced (configured). The latter is not relevant given the recirculating HVAC systems present in the housing units at the Metropolitan. There are many ways to measure or estimate both infiltration rates and inter-zonal flows that could lead to infiltration and migration of air between interior spaces; [18] no such measurements at the Metropolitan were conducted.

Given that prevailing wind conditions were calm, very light or light winds, as discussed in Section 4.1 and Table 1, wind-induced pressure differences in the Metropolitan buildings would have been negligible, thus wind-induced infiltration would be negligible.

Given that the outdoor temperature was 71-72 °F for most of the fire (Table 1), very close to indoor temperatures expected in the housing units, the indoor-outdoor temperature difference is negligible. The similar indoor-outdoor temperatures mean that there is no or minimal temperature-induced pressure difference or stack effect, thus temperature induced infiltration would be negligible.

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[18] My group (including collaborations with US EPA and others) conducts research addressing infiltration, air change rates, and interzonal transport in buildings and pollutant migration, including a variety of health related applications and advances in measurement and assessment approaches. Examples of peer-reviewed publications include:

Liuliu Du, Stuart Batterman, Christopher Godwin, Jo-Yu Chin, Edith Parker, Michael Breen, Wilma Brakefield, Thomas Robins, Toby Lewis "Air change and interzonal flows in residences, and the need for multi-zone models for exposure and health analyses, *International Journal of Environmental Research and Public Health*, 2012 9(12): 4639-4661.

Breen, Michael S., Janet M. Burke, Stuart A. Batterman, Alan F. Vette, Gary A. Norris, Christopher Godwin, Carry W. Croghan, Bradley D. Schultz, Thomas C. Long. Modeling Spatial and Temporal Variability of Residential Air Exchange Rates for the Near-Road Exposures and Effects of Urban Air Pollutants Study (NEXUS). *International Journal of Environmental Research and Public Health*, *11*(11), 11481-11504, 2014;

Batterman, S., Luilui Du, Christopher Godwin, Zachary Rowe, Jo-Yu Chin, "Air exchange rates and migration of VOCs in basements and residences," *Indoor Air*, 25, 6, 598-609, 2015.

Carrilho, João Dias, Mário Mateus, Stuart Batterman, Manuel Gameiro da Silva. "Air Exchange Rates from Atmospheric CO_2 Daily Cycle, *Energy and Buildings*, 92, 188-194, 2015. doi:10.1016/j.enbuild.2015.01.062.

Batterman, S., "Review and Extension of CO_2-Based Methods to Determine Ventilation Rates with Application to School Classrooms," *International Journal of Environmental and Public Health Research,* 2017, 14, 145; doi:10.3390/ijerph14020145

Batterman, S., Feng-Chiao Su, Andrew Wald, Floyd Watkins, Christopher Godwin, Geoffrey Thun. "Ventilation Rates in Recently Constructed US School Classrooms," *Indoor Air*, 5: 880-890, 2017.

The lack of both wind- and temperature-driven effects affecting the indoor-outdoor pressure differential means that air infiltration through the building envelope would be minimal during the fire period.

4.3 Infiltration and particle penetration

Infiltration refers to the entry of outdoor air through the building envelope, including through very small cracks and pores. Particles in outdoor air may not be able to cross the building envelope and enter the building in the same manner as air since particles are very large and heavy relative to molecules of air, among other differences. The entry of particles into a building is called *particle penetration.* The ability of particles to enter a building is characterized by *penetration efficiency*, which depends on the physical and chemical properties of the pollutant and the building envelope, and the environmental conditions. The penetration efficiency of soot, char and ash can vary considerably due to their different properties, including their size, as noted below.

- Soot is a submicron (less than 1 µm) black powder[19] formed largely from "aciniform carbon," which is defined as colloidal carbon having a morphology consisting of spheroidal primary particles (nodules) fused together in aggregates of colloidal dimension in a shape having grape-like clusters or open branch-like structures; the colloidal particles are typically 20-50 nm in size (0.02 – 0.05 µm);[20] soot aggregates, chains and clusters are larger and span a large size range.
- Char is carbonaceous material that preserves the morphology of the precursor (e.g., wood) and includes particles greater than 1 µm size; [21] particle size may reach several mm (~2000 µm) though 1 – 500 µm is more typical.[22] The EMSL analyses showed char particles with sizes about 50-100 µm, [23] about the thickness of a human hair.
- Ash is the decarbonized residue of cellulosic material (e.g., burnt char), which may not preserve the original morphology and may have higher concentrations of inorganic compounds and be alkaline. Size can vary considerably, e.g., 0.5 to 1000 µm. [24]

Penetration efficiency depends strongly on particle size.[25] Penetration efficiency will be relatively high (roughly 75%) for particles in the range of 0.02 to 0.5 µm dia (smaller soot), decrease to roughly 30% for 5 µm diameter particles, and continue to fall, potentially much lower, for large particles, e.g., 50-100 µm char particles. Relevant estimates of penetration efficiency for large particles are not available in the literature.

The key points are (1) that penetration of particles through the building envelope differs from air infiltration, and (2) that penetration of large particles like much char can be substantially reduced.[26]

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[19] AIHA 2018. Ibid.

[20] ASTM, D6602−13. Standard Practice for Sampling and Testing of Possible Carbon Black Fugitive Emissions or Other Environmental Particulate, or Both, West Conshohocken, PA, 2018.

[21] ASTM, 2018, ibid.

[22] Kovar, B, ML King, P Chakravarty. Suggested guidelines for wildfire smoke damage investigations and remediation. J Cleaning Restoration and Inspection, June 2015.

[23] EMSL Analytical, Inc. Laboratory Report - Common Particle Identification Combustion-by-Products; Project: The Metropolitan 200 Route 130 North, Cinnaminson, NJ 08077. June 17, 2019.

[24] AIHA, 2018, ibid.

[25] Long, CH, et al. Using Time- and Size-Resolved Particulate Data To Quantify Indoor Penetration and Deposition Behavior, *Environ. Sci. Technol.* 35, 2089-2099, 2001.

[26] FBS, ibid. June 2020. On p. 19, FBS asserts: "It is important to note that negative pressures are less than ambient pressure, and positive pressures are greater than ambient pressure. When this condition exceeds the design of the building or the

4.4 Summary: limited potential for exposure, infiltration and penetration of fire-related pollutants

The Phase 1-3 buildings had little potential for significant exposure, air infiltration and particle penetration of fire-related pollutants. These buildings had neither the exposure nor a completed pathway required for the entry of fire-related combustion materials into the building. This is shown by the duration and dynamics of the fire, the prevailing meteorology, plume direction, the building configuration, the lack of conditions needed to cause infiltration and particle penetration through the building envelope, and the low penetration efficiency of large particles. This is further supported by the sampling results that showed few if any signs of combustion residues with moderate or high likelihood despite numerous samples collected (Section 6).

A portion of Phase 4 and Phase 5 had limited potential for smoke exposure due to their locations with respect to the prevailing winds and plume direction, however, the pathway for entry of fire-related combustion residues was not completed and thus the penetration of fire-related combustion residues into the building is likely to be minimal. Because the building envelope remained intact, the prevailing meteorology greatly favored vertical plume rise, and the conditions needed to cause air infiltration and particle penetration were absent, the likelihood that significant amounts of fire-related combustion residues entered these building is small. This is supported by the analysis of samples that showed moderate or high likelihood of combustion residues in very few and localized areas (Section 7).

The limited entry and presence of fire-related combustion residues in any of the Phase 1-6 buildings will be far too small to confer any meaningful risk of adverse health effects (Section 7).

5 Collection and Analysis of Samples by FBS

FBS conducted a number of inspections and collected environmental samples at the Metropolitan from Jan. 9, 2019 through August 27, 2020 that are pertinent to the assessment of fire-related combustion residues. The record shows a total of 15 sampling visits in which 471 samples were collected and analyzed. Samples included air (Air-o-cell cassettes), surface (tape and wipe) and bulk samples with analysis by two laboratories. For 14 of these visits, samples were analyzed optically by N.G. Carlson Analytical; the May 30th, 2019 visit used a "level 4" analysis that included soot confirmatory analysis using ASTM D6602 protocols conducted by EMSL. Results of all samples are presented in Table 2 and Appendix 1.

5.1 Sampling results

5.1.1 May 30, 2019 sampling

Following an initial site visit on April 24, 2019, FBS visited the site to "conduct soot sampling" on May 8, 2019; a second round of sampling occurred on May 30, 2019. FBS provided results of the sampling in a report dated June 5. 2019.[27] This section discusses the May 30, 2019 samples analyzed by EMSL. (All other samples collected by FBS were analyzed by N.G. Carlson Analytical.)

Table 2 lists results for the 20 wipe samples analyzed by EMSL.[28] The purpose of the EMSL analysis was to determine the identification of the collected particles, based on individual components (common components of environmental dust and combustion-by-products) using several analysis techniques, e.g., Polarized Light Microscopy (PLM), epi-Reflected Light Microscopy (RLM), Transmission Electron Microscopy (TEM),

design is compromised, say by a fire, heat or water from the fire infiltration will occur at the failure points." This is an incorrect description of infiltration.

[27] FBS. Fire Damage Report for The Metropolitan, June 5, 2019

[28] EMSL Analytical, Inc. Laboratory Report - Common Particle Identification Combustion-by-Products; Project: The Metropolitan 200 Route 130 North, Cinnaminson, NJ 08077. June 17, 2019.

Scanning Electron Microscopy (SEM), Energy-dispersive X-Ray Spectrometry (EDX), Electron Microscopy. Of most interest is soot, ash, and char, described by EMSL as:

- Black Carbon (Soot): a randomly formed particulate of carbon, commonly with a spherical to pseudo-spherical (aciniform) morphology. It is a by-product of uncontrolled combustion.
- Carbonized Material/ Char: a solid decomposition product of natural or synthetic origin that maintains, at least in part, its original form.
- Ash: Residue left after complete carbonization of the material. It does not maintain its original form.
- Charcoal: a term for char obtained from wood, peat, coal or other organic material.

EMSL notes that their limit of quantitation is ~1%. Two of 20 samples indicated the potential for fire-related residues: Sample 1A, identified as Phase IV – 4th Floor – Floor Truss, containing an estimated 15% char, and Sample 7A, identified as Unit 115 – bedroom window sash, containing an estimated 40% char. The PLM images for these samples show char particles on the order of 50-100 µm in size. No black carbon or other combustion products were identified in these samples. None of the other 18 samples indicated other fire-related material above the limit of quantitation, essentially showing normal or trace levels of combustion residues. The interpretation of the sampling results is hampered by documentation gaps, including the absence of the custody forms, sampling collection protocols, detailed maps and photographs of sampling locations (Section 5.2). The FBS report describing this sampling[29] contains a number of misleading and erroneous statements and data interpretations[30] (Section 5.2.4).

[29] FBS, Supplemental Sampling Report, Forensic Building Science, Inc., Nov. 13, 2019.

[30] FBS, Nov. 13, 2019, ibid. For example, the report states that: "the results of the second round of sampling confirmed the presence of soot on surfaces throughout the structure," (p.2), and "17 surface samples showed signs of particulates consistent with the fire." (p. 3)

Table 2. Results for 20 wipe samples collected by FBS on May 30, 2019 and analyzed by EMSL. Percent of particles shown. Two samples highlighted where char was detected above the level of quantitation.

Descriptor		1A Phase IV – 4th Floor – Floor Truss	2A Unit 404 – closet door header	3A Unit 422 – Living room - baseboard	4A 4th floor – SW maintenance closet – N. painted drywall	5A Unit 217 – Bedroom door header	6A Unit 221 – bathroom closet door header	7A Unit 115 – bedroom window sash	8A Unit 117 – living room – upper window sill	9A Unit 121 – entry door header	10A Unit 122 – Laundry room baseboard	11A Unit 217 – kitchen can light fixture – ceiling cavity	12A 2nd floor – SW maintenance closet – top of meter	13A 2nd floor – W. hallway (outside 202) top of emergency light	14A 2nd floor – W. hallway (outside 324) Painted drywall	15A 3rd floor – NW maintenance closet – E. painted drywall	16A 3rd floor – S. hallway (outside 316) ceiling access cavity	17A 3rd floor – NW maintenance closet – E. painted drywall	18A 3rd floor – W. hallway (outside 304) ceiling access cavity	19A 4th floor – N. hallway (outside 430) top of emergency light	20A 4th floor – W. hallway @ stairway – tip of fire extinguisher
Combustion-by-products	Char	15	<1	<1	<1	<1	<1	40	<1	<1	ND	<1	<1	<1	<1	ND	<1	ND	1	<1	<1
	Ash	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Black Carbon /Soot	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Carbon Black	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Asbestos:	Total	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMVF's:	Total	<1	<1	ND	ND	<1	<1	<1	<1	ND	ND	<1	<1	<1	ND	ND	2	ND	2	1	<1
Cellulose:	Processed / Paper Pulp	30	10	15	20	10	10	10	5	2	10	10	2	5	30	10	25	5	15	5	5
	Natural / Wood Dust	<1	<1	ND	<1	<1	<1	<1	<1	ND	ND	<1	ND	ND	ND	ND	ND	ND	2	ND	ND
	Starch	<1	ND	ND	<1	ND	ND	ND	ND	ND	ND	ND	ND	ND	<1	ND	ND	ND	ND	ND	ND
Synthetics:	Total	5	2	30	25	10	30	15	25	10	10	20	10	10	15	15	15	10	5	15	20
Hair:	Human	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Animal	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Biological:	Skin Fragments	<1	ND	<1	ND	<1	ND	<1	ND	ND	ND	1	ND	<1	<1	<1	ND	ND	<1	<1	<1
	Insect Fragments	<1	<1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1	ND	ND	ND	<1
	Dust Mites	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Spider Silk	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Mold	<1	<1	ND	ND	ND	ND	<1	<1	ND	ND	ND	ND	<1	ND	<1	<1	ND	1	<1	<1
	Pollen	<1	<1	<1	ND	<1	ND	<1	<1	ND	<1	ND	ND	<1	ND	ND	<1	ND	<1	<1	<1
Mineral:	Quartz (Sand)	5	15	5	2	10	2	10	10	15	2	2	20	10	5	5	5	2	10	15	10
	Calcite/ Dolomite	2	15	5	2	20	10	5	30	30	2	2	15	30	5	5	5	2	5	20	20
Sample Specific	Gypsum/Anhydrite	2	5	2	1	5	N/A	1	5	7	15	35	2	10	2	1	10	1	25	10	10
	Environmental Dust**	34	47	40	47	40	45	14	20	35	60	27	49	30	40	62	34	80	32	30	29

5.1.2 Jan. 9, 2019 and May 8, 2019 through Sept. 11, 2020 sampling.

In 14 sampling events (several spanning 2 days), FBS collected 451 air, bulk and tape samples, subsequently analyzed by NG Carlson Analytical. As noted in each Carlson report, "no chemical identification was conducted on the soot-like, char-like particles, and carbon black-like particles. Presumptive identification was based on particle morphology." Quantitation appears to use particle counts; no standard operating procedure was provided, a deficiency discussed in Section 5.2.[31] Each report provides tabular results, a short discussion, custody forms, and for selected samples, micrographs and some notes.

The air samples appeared to use 30-75 L samples (some volumes are not documented), Aer-o-cell cassettes, and light microscopy analysis. Air samples were reported on a non-standard scale of 1 to 50+, which appears to be the average number of particles per field view at 400x power (p. 5).[32] Because the air samples used at least two sampling volumes (30 L, 75 L, and "XX" L – the latter which cannot be interpreted), adjustments to the data may be warranted to allow inter-comparison of samples, both within and between sampling events; such adjustments are not documented and do not seem to have been performed.

Table 3 summarizes the data collected in these 14 visits; the full set of NG Carlson data has been consolidated and is presented in Appendix 1.

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[31] NG Carlson noted the following in each report to interpret carbon black, char and soot-like particles: "Less than 0.5 particles per field (400x) – negligible impact of smoke; 0.5 and 2.0 particles per field (400x) – limited impact of smoke; 2.0 and 10 particles per field (400x) – moderate impact of smoke; 10 – 50 particles per field (400x) – significant impact of smoke."

[32] Carlson NG, Expert Report, 10/5/20. In this report, p. 5 noted that the concentration (#/m3) can be obtained by using the score or average count reported and the sampling volume. Examples are given that show that the concentration (#/m3) = (average count reported per view) x (field views per trace) / (volume sampled in m3). It also states there are nominally 25 field views per trace. This is considerably fewer than the 100 views suggested in some standards and guidelines. The concentration calculation appears to imply that the entire trace is covered without double counting. It also does not represent the number density or area density of potential combustion residues, which are the more standard approach in this application. Most significantly, it also means that the same score has a different interpretation for samples with different sampling volumes, i.e., a score of 2 with a sampling volume of 30 L means a concentration that is 2.5 times higher than a score of 2 with a sampling volume of 75 L. Although relatively few air samples showed significant likelihood of combustion residues, it appears that adjustment of the data is required to compare the 30 and 75 L sample results. Specifically, the 75 L samples may have 2.5 times the level shown for a 30 L sample, other things being equal.

Table 3. Summary of 15 sampling events conducted by FBS at the Metropolitan.

Sample Date	Type and quantity	Location	Findings	Interpretation	No. high likelihood	Errors
1/9/19	25 air samples collected	Phases 1-3?; main level and 4th floor	6 samples with moderate likelihood of combustion residues; 7 samples with high likelihood of combustion residues (most identified as "carbon black", however, 9 of these in kitchen areas.	Most samples show normal conditions; some samples may contain cooking-related carbon particles; high likelihood of combustion particles identified in corridor in 2 samples (7, 12)	2 samples in corridor	Sample 9 reports <11 for char; samples inconsistently report soot, carbon black, and combined soot/carbon black. Inadequate documentation, e.g., cannot tell which samples had "sterilized inner-wall sampling adapters were used at select predetermined locations and cavities".
1/28-29/20	32 air samples collected	Phase? 3rd and 4th floors	All negative or trace; one kitchen sample showed low combustion residues (3-4% char)	All samples show normal conditions; one sample shows low likelihood of combustion residues, but may be kitchen related material	0 samples	No outside air sample for comparison
	49 tape and 3 bulk samples collected	Phase? 3rd and 4th floors	1 bulk sample on sheetrock in Unit 422 (47B) showed medium likelihood of combustion residues ; 1 tape sample in Unit 307 on bedroom wall (69T) showed high likelihood, but notes indicate could be paint particles, which are widespread	All samples identified as normal condition, except 1 sample with medium likelihood of combustion residues	0 samples	Paint-like particles inconsistently characterized, e.g., micrograph for sample 67T describes paint, but not quantified in data
2/25/20	15 air samples collected	Phase? 3rd floor	All negative or trace	Normal conditions	0 samples	No outside air sample collected. No air sampling volume reported. No calibration for pump indicated. Cannot interpret adequately. Report indicates samples collected Feb 13 2020 and Feb 25, 2020. Former date appears incorrect.
	18 tape and 2 bulk samples	Phase ? 3rd floor	All negative	Normal conditions	0 samples	
3/11/20	18 air samples collected	Phase ? 2nd and 3rd floors	All negative	Normal conditions	0 samples	No outside air sample for comparison. Noted as 2-min samples, presumed to be 30 L, but no documentation. Discussion states "Char and Soot levels varied from Negligible to Limited on the Air-o-cell cassette samples" but no PFRS quantified.
	20 tape and 2 bulk samples collected	Phase? 2nd and 3rd floors	All negative	Normal conditions	0 samples	Discussion states "Char and Soot levels varied from Negligible to Limited on the bulk and tease tape samples" but no PFRS quantified.
3/19/20	14 air samples collected	Phase ? Mostly 1st floor. Some unknown.	All negative	Normal conditions	0 samples	No outside air sample for comparison. Noted as 5-min samples, increase from prior practice. No calibration or volume given. presumed to be 30 L, but no documentation.
	13 tape and 1 bulk sample	Phase ? Mostly 1st floor. Some	All negative	Normal conditions	0 samples	
3/24-25/2020	13 tape samples collected	Phase 5, mostly 4th floor other	All negative except for 1 sample (11) for unit 427 bedroom window sheathing showing 1-15% of char	Normal conditions, or moderate likelihood of fire residues	0 sample (taking most likely value)	Large range; could resample location.
4/7/20	5 bulk and 1 tape (uncertain documentation) collected	Phase ?, northwest and southwest corners?	All negative except sample 5 low (2-4%) char on Zip sheathing	Normal conditions; low likelihood of combustion residues	0 samples	Standard chain of custody form not used; Inconsistent labeling: Sample 4 indicated as tape sample in report; sample 6 indicated as bulk sample on hand written documentation (p100 report)

Table 3 continued

Sample Date	Type and quantity	Location	Findings	Interpretation	No. high likelihood	Errors
4/8/20	4 air samples collected in elevators 1 and 2	Phase? Floors 1 and 4	3 negative, but sample 4A (elevator 1, floor 4) shows 5-10% char, but note indicates "The char shape was irregular and could be a false positive."	Normal conditions; low likelihood of combustion residues	0 samples	
5/8/20	25 air samples collected in phases 1-4 at all levels	Phases 1-4; Ground floor, 1st-4th floors	6 samples showed moderate levels of char or soot (5-10%); 5 samples showed high levels of char or soot (11-50%); Highest (sample 29) was kitchen island in Unit 336; Two highest samples (29 and 31) stated to have very heavy trace and note indicates count is approximate	Most samples show normal conditions; 6 show medium likelihood of combustion residues in phases 1-3; high likelihood of combustion residues in 3 samples in phases 1 and 3; possibly high likelihood in 2 additional samples	3 to 5 samples	Volume of sample changes from 30 to 75 L without rationale no calibration noted; No outside air sample for comparison. Micrographs of most highly loaded filters not provided.
	44 tape samples, 3 bulk samples of insulation or air filter	Phases 1-4, floors 1-4	15 samples showed moderate levels (5-10%) of char, soot or carbon black on roof AC cover, hallways, window sill, closet outlet boxes, "above" doorways, subfloor dryer ducts. 16 samples showed high levels of these components, included samples in Unit 219, mechanical room in Phase 1, joist near Unit 240; surfaces in Units 344, 438, 138, 452, 457, ; unspecified exterior behind sheathing in Phase 1. High levels found on several exterior wall samples behind siding and in joist	Unlike prior sampling due to higher levels of char, soot, carbon black. Some samples show normal conditions; 15 show medium likelihood of combustion residues; 16 show high likelihood. Units 219 and 348 show high likelihood in both air and tape samples. More samples show combination of soot, char, ash than most other sampling.	16 samples	Locations on exterior walls not specified. Micrographs provided for only 6 samples
5/30/19	20 wipe samples collected; analyzed by EMSL	1st - 4th floors, some cavities	18 samples negative or trace. 2 samples with high char (1A; Phase 4 4th floor truss; 7A Unit 115, bedroom window sash); Stated to be comparison with 5/8/20 sampling;	Most samples show normal conditions; two show high likelihood of combustion residues.	2 samples	Report states "the results of the second round of sampling confirmed the presence of soot on surfaces throughout the structure"; and "17 surface samples showed signs of particulates consistent with the fire"
7/16/20	17 air samples collected	7 samples appear to be in parking area or storage area, uninhabited area; 9 samples from 4th floor	For the parking samples: 3 samples show moderate char; 2 samples show high char. For the 4th floor samples, 2 samples show moderate char. The outdoor sample shows high char (10-15%)	The outdoor sample exceeds all but 2 samples, which were collected in the parking area. May represent baseline or background level, indicating no combustion projects detected except for 2 samples in the parking area.	2 samples (uninhabited area)	Several samples use the same identification number, 1A, 4A, 14A. Only micrographs for 11A and 14A (from garage) are included.
	26 tape and 1 bulk sample collected	9 in parking area, not inhabited area; 16 mostly on 4th floor	For the parking area samples: 1 sample show moderate char and 2 show high char. For the indoor samples, 2 samples shows moderate char and 2 samples showed high char; these indoor samples are sheathing or studs around units 441 and 442.	High likelihood of combustion residues on 2 indoor samples, appear to be under sheathing or on studs	2 samples in occupied area; 2 samples in uninhabited area)	Several samples use the same identification number, 2T, 5T, 6T, 10T, 15T. Only selected micrographs are included. (3 samples with char)
8/11-12/2020	14 air samples collected	Outside and 3rd and 4th floors	All negative or trace	Normal conditions.	0 samples	
	12 tape samples collected	3rd and 4th floors	All negative or trace	Normal conditions.	0 samples	
8/25/20	14 air samples collected	3rd and 4th floors	All negative or trace	Normal conditions.	0 samples	No outdoor sample collected as reference or background.
	20 tape samples collected	3rd and 4th floors	All negative or trace except for soot (20-30%) in Unit 303 mechanical room, however, notes on this sample indicate "particle similar to soot" but largely paint	Normal conditions with one uncertain sample, possibly high likelihood	Possibly 1 sample	Lacking recheck of suspect sample; Unit 38 entered but no such space
8/27/20	8 air samples collected	2nd floor	Negative or trace for all samples except 1 sample (P) fire equipment area near Unit 236 with high char (20-25%) however noted as "atypical char", not noted in Discussion. Micrograph for this sample shows mold Cladosporium, not char	Normal conditions at all but one location with high char but note indicates atypical, thus discounted.	0 samples.	No outdoor air reference or comparison sample. No micrograph of suspect sample showing char.
	8 tape samples collected	2nd floor	All negative or trace	Normal conditions.	0 samples	
9/11/20	12 air samples collected	Mostly phase 4, floor 1	All negative or trace	Normal conditions likely, however, QA is absent due to reporting omissions.	0 samples	Does not specify volume of air sampled; Did not specify location. Added location from custody form.
	12 tape samples collected	1st floor	All negative or trace	Normal conditions	0 samples	Custody form inappropriately utilized

5.2 Evaluation of FBS sampling, analysis, and interpretation

The 15 sampling events at the Metropolitan included the collection and analysis of airborne, wipe, surface and bulk samples. This section evaluates data quality, and the analysis and interpretation of this data by FBS.

5.2.1 Lack of sampling design suitable for assessing indoor environmental quality

The purpose of FBS's sampling appears to be to determine whether fire-related combustion residues (i.e., ash, char and or soot) had spread to other parts of the structure.[33] NG Carlson Analytical notes that some reports are "initial screenings" (report #14); other reports <unspecified report number> are "focused on the effectiveness of remediation and identifying by the arson fire and if there may be possible interior sources of fungal growth. Additional reports focused on the effectiveness of the remediation techniques and identifying other areas of concern as wall cavities were opened. Subsequent reports also addressed concerns about fungal growth as thought to be attributed to the fire suppression or concerns about water infiltration of the building envelope."[34] This suggests that at least some of the sampling represented a screening level approach, typically used to determine whether additional sampling is warranted. Most determinations of combustion residues, specifically soot, char and ash, were based on optical analyses, and excepting the 20 EMSL-analyzed samples, no chemical analyses of the collected samples were performed.

FBS collected and analyzed 198 air samples, collected from Jan. 1, 2019 through Sept. 11, 2020, 96 to 715 days after the fire. Except for the initial 25 samples, the air samples were collected starting on Jan. 28, 2020, 488 days after the fire. Char, soot ash or other fire-related combustion residues from the Sept. 27, 2018 fire could not stay airborne in a building environment for this period of time. Rather, the air samples most likely reflect contemporary sources of particles (e.g., cooking, cigarette smoke, outdoor pollutants, etc.) and not fire-related combustion residues unless materials were recently disturbed (e.g., during or prior to sampling). As noted below, it is essential to obtain background or reference measurements for environmental sampling to show whether measurements are elevated beyond normal conditions. This is particularly important for air samples as indoor and outdoor levels can change rapidly in time.

The sampling and analysis conducted by FBS at the Metropolitan were not designed to determine whether fire-related combustion residues compromised indoor environmental quality or could cause adverse health impacts of occupants at the Metropolitan. Such sampling would address the potential for occupant exposure and health risks from toxic substances. Instead, sampling focused on visual analysis and optical analyses of the presence of char, ash and soot on building surfaces and building cavities. As noted later in Section 7, a number of the locations sampled would present extremely limited potential for exposure and health impacts even if combustion residues were identified. FBS did not obtain or present any data regarding the concentration of potentially toxic chemicals in the detected combustion residues, and FBS did not conduct a quantitative assessment of the potential to cause adverse health effects.

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[33] FBS, p. 49, June 2020 and Oct. 5, 2020 (p. 67) state: "The primary purpose of the sample collection was to determine whether ash, char and or soot consistent with base line samples taken from the surviving portion of the building closest to the fire-destroyed building had spread to other parts of the structure. Our investigation focused on hidden cavities typically overlooked during smoke damage cleaning efforts. These included the wall cavities, ceiling assemblies, mechanicals, electrical boxes and areas around the elevator hoistway in the building to aid in determining a proper scope of repair."

[34] NG Carlson, Expert Report in the Case of Maxus/The Metropolitan, Oct. 5, 2020.

5.2.2 Failure to follow standard sampling and analysis procedures

Sampling and analysis procedures and reporting by FBS and their consultants have numerous serious flaws and do not comply with standard practices, for multiple reasons (e.g., IESO/RIA Standard – 6001)[35] Some of these are indicated in the data summary shown in Table 3 (right hand column). Flaws include:

- Lack of blanks needed to assure appropriate sample collection practice and sample integrity during sampling, transport and storage of samples.
- Omission of standard operating procedures (SOPs) for collecting, labeling, transporting, storing, analyzing and interpreting samples and analytical data.[36] This includes the *chain of custody of samples*, which is largely unknown.
- Unknown adherence to SOPs, if they existed. This is exacerbated by the documentation gaps for the field activities. The documentation available shows many errors.
- Inadequate documentation, e.g., failure to include, for each sample, photographic documentation of inspection and sampling location surface (including type of surface, size/weight of area sampled, whether it was interior, exterior or cavity space, etc.)
- Documentation errors, e.g., samples taken at locations that do not appear to exist (e.g., Unit 38) and without specificity sufficient to identify sample locations (e.g., "NW corner of building sheathing", "corridor outside stair enclosure"), and air sample volume ("XXX"). Maps of sampling results are largely illegible and impossible to interpret or verify.
- Insufficient detail and inconsistent use of data entry forms for field sampling.
- Inconsistent and non-standard means to sample, quantify and present results of air sampling. In addition to the quantification issue (see footnote 32 earlier), NG Carlson noted that the air samples were short duration samples (1-5 minutes) with sampling time (or sample volume) based on "the professional judgment of the person doing the sampling with feedback from the person analyzing the sample" (p. 5). My review showed sampling times from 2-5 minutes without documentation as to why some samples had shorter or longer sampling periods and how this would have affected results.

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[35] IESO/RIA Standard 6001: Evaluation of Heating Ventilating and Air Conditioning (HVAC) surfaces to Determine the Presence of Fire-related Particulate as a result of A Fire in a Structure. Indoor Environmental Standards Organization. 2012.

[36] The best description of the sampling approach appears to be in the FBS Fire Damage Report, June 5, 2019, p. 34-5: "All air samples were collected with a Zefon Bio-Pump Plus air sampling pump calibrated to run at a volume of 15 liters per minute. The sample duration varied by location. The air samples were collected with Air-O-Cell sampling cassettes using standard accepted sampling techniques. Analysis of all Air-O-Cell cassettes was by a CIH and was presumptive consistent with industry accepted norms and based on the training, education and experience of the industrial hygienist.

The ambient air samples were collected for a five-minute sample period to use for comparison purposes. The wall cavity air samples were collected with the use of a sterile wall cavity adapter tube. Each tube was used only once, then discarded. At each wall cavity, the tube was inserted into the wall/ceiling or conduit/pipe space as far as possible.

The tape lifts were collected on wall or ceiling surfaces where the presence of char and soot was suspected to exist. There was evidence of extensive cleaning and demolition associated with repairs after the fire. Bulk samples of furnace filters were taken from units that were available to rent to determine if contaminants were present in the ambient air. Tape lifts were analyzed using four different methods to compare with presumptive Air-O-Cell cassettes sample analysis. Concurrent tape lift samples were taken at the origin location along with numerous other locations for baseline comparison purposes between presumptive analysis and more definitive analysis." Emphasis added.

- Inconsistent and qualitative mold sampling. In a most cases, a few mold species were identified optically and recorded with a "+", "++", "+++", or "++++". These marking are not quantitative,[37] and species identification is inadequate. In a few cases, mold concentrations were expressed as counts per cubic meter, the standard approach. The SOP utilized for mold is undocumented.

- Failure to use a certified laboratory. Laboratories that are certified in recognition of their ability to process samples and generate data that meets a minimal standard of quality and performance. Certifications by AIHA, CNAS and others are customary practice, well recognized, and essential. The bulk of analyses at the Metropolitan were performed by NG Carlson, Inc., a laboratory that does not appear to have any certification. For critical applications (and frankly to obtain business), laboratories obtain certifications, undergo regular audits and inspections, often by third parties, test QA samples, and perform many other activities aimed at documenting and maintaining the quality of protocols and results obtained. This deficiency is particularly critical when laboratory results inform significant decisions since the reliability of results is unknown. The lack of certification is often a sufficient reason to dismiss analytical results.

- Failure to have a certified industrial hygienist approve and monitor implementation of the sampling plan. Professional certifications by AIHA and others are well recognized and provide a level of assurance that the data generated will meet a minimum standard of quality and relevance to a defined problem. No peer-review of the sampling plan, data, or analysis was evident. Errors and omissions documented throughout this section demonstrate the significance of this failure.

5.2.3 Failure to measure and account for normal and background levels in sampling and analysis

It is well known that there are many sources of combustion residues in the environment and that samples collected must be to a reference or comparison level.[38] No reference or comparison samples were collected in most sampling events, and no comparisons to references levels were performed. While several air samples were collected that were noted as outdoor or ambient samples that may serve the purpose of a reference sample, no tape or bulk samples were designated as reference or comparison level samples, and no comparisons were made.

A low or trace level of a combustion residue reported in a sample does not indicate a meaningful likelihood of a fire-related impact. FBS implied that any detection of char, soot or ash, including <1%, indicated significant fire-related impacts. This fails to comply with the need (and guidance and customary practice) to use comparisons to reference levels to interpret sampling results. At the Metropolitan, one result of this practice is to produce *false positives* and *phantom risks* (Sections 5.2 and 6).

Accounting for background or reference levels is important for all types of samples. As in many urban areas, there is an abundance of sources of soot and other combustion residues near the Metropolitan. These include major highways and traffic-related sources and food establishments, especially those using grilling, barbequing,

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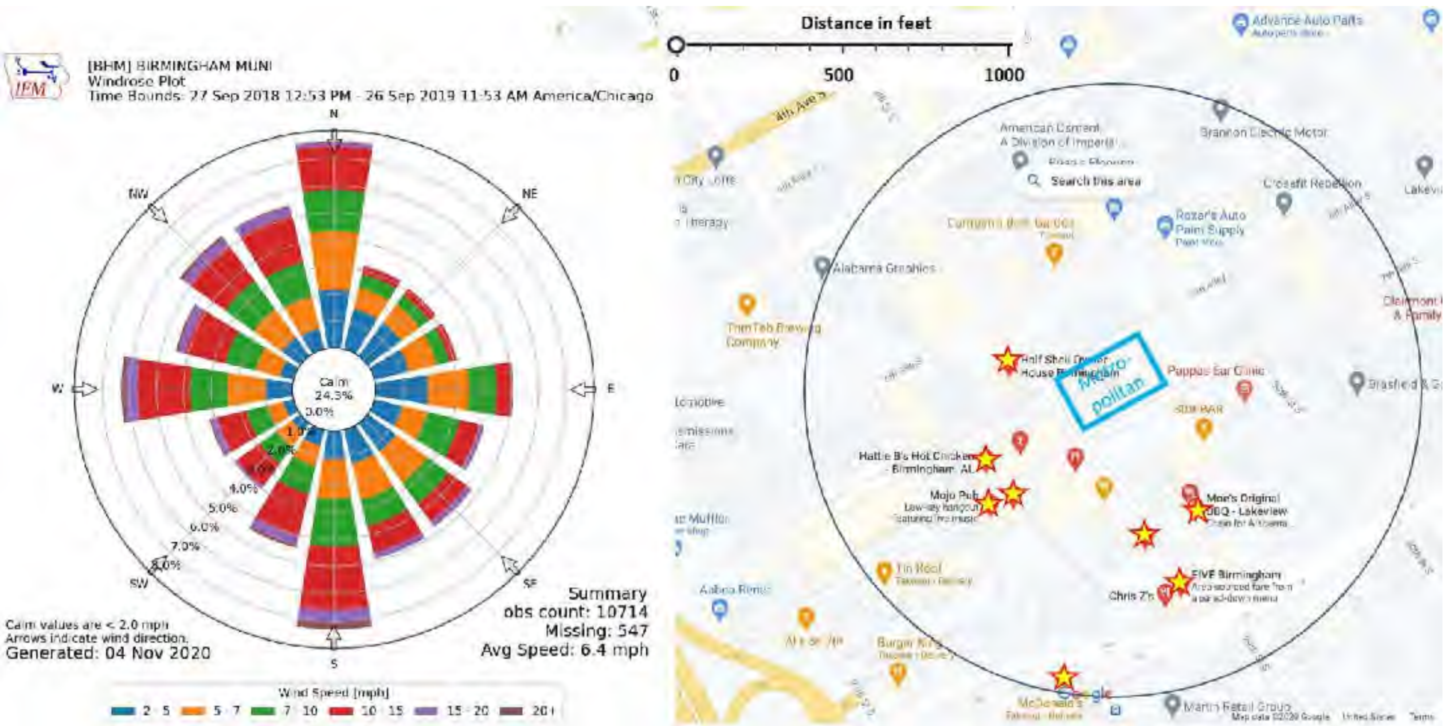
[37] Addendum C – Carlson Report, p. 54 provides some explanation, but the modifications are not document. The Report notes: "Fungal spore interpretation: Modified from IICRC S520. 0 No spores present + Normal spore deposition; ++ Heavier than normal spore distribution no growth noted; +++ Spotty fungal growth; ++++ Heavy Fungal growth."

[38] AIHA 2018, ibid, states (p18): "… establishing a baseline by determining normal background concentrations for the subject site are key in interpretation of field data. EPA 838/08 Site Contamination – Determination of Background Concentration and EPA 540/F-94/030 Establishing Background Levels specify that background sampling locations must be selected from areas on the site or near the site not known to be impacted by combustion particles from the fire event. Combustion particles from everyday activities such as wood burning fireplaces, stoves, candles, cigarettes, and vehicle exhaust are part of the background. Emphasis added.

As an example of the disregard for consideration of normal background levels, the Fire Report, p 59, states: "Of the 72 air, tape and bulk grab samples taken and submitted for analysis, some level of byproducts consistent with the fire were found in all the samples, including soot, char, and ash (100%). Of the 72 samples taken and submitted for analysis, 12 samples showed less than 1% of soot, char, and ash. The remaining 60% of samples had results in excess of 1%. "

smoking and frying, all known to emit significant quantities of soot and carbon aerosols. There are many such establishments in Birmingham and the Lakeview area, including at least eight within 1000 feet of the Metropolitan, some of which may burn wood. Figure 8 shows locations of restaurants serving grilled, barbequed and fried foods, e.g., Hattie B's Hot Chicken within 300 feet of the Metropolitan, and Moe's Original BBQ within 375 feet. The Metropolitan is frequently downwind of these restaurants, as shown by the wind rose in Figure 5.[39] A significant background level of PAHs is expected and from such sources, which is confirmed by air pollution measurements at four Birmingham locations where the most toxic PAH (BaP) exceeded health-based screening levels, i.e., BaP in ambient air averaged 0.002 $\mu g/m^3$ and reached 0.015 $\mu g/m^3$, or 7.5 times the screening level discussed in Section 7.3.[40]

Figure 5. Left: Wind rose from the Birmingham Airport for the 1 year period following the fire. Right: Map identifying restaurants (as stars) that grill, barbeque or fry foods within 1000 feet buffer of Metropolitan using Google Maps,



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39 Wind rose shows direction wind is blowing from. Using data from Birmingham airport. Generated using Iowa Environmental Mesonet: Wind Rose Plotsttps://mesonet.agron.iastate.edu/sites/dyn_windrose.phtmls.

40 Jefferson County Department Of Health, Birmingham. Air Toxics Study. February 2009 https://www.epa.gov/sites/production/files/2020-01/documents/jeffersoncountyfr.pdf. On p.36: Benzo(a)pyrene is a polycyclic aromatic hydrocarbon (PAH) that exceeded the chronic cancer risk at North Birmingham and Shuttlesworth. This compound is highly carcinogenic and its emissions are closely associated with coal tar, automobile exhaust, cigarette smoke and wood-burning.

5.2.4 Flawed and misleading interpretations and conclusions by FBS

FBS describes the generic nature of fire pollutants and settled combustion residues and concludes that their presence is hazardous.[41] There is little if any relevant documentation that supports this conclusion, e.g., no consolidation of data, no analysis by location, no consideration of exposure potential, background or reference levels, no relevant chemical analysis, and no discussion of cleanup and restoration practices that would inform an evidence-based conclusion.

5.3 Summary

The FBS sampling and analysis at the Metropolitan has many significant flaws and omissions. These include significant documentation gaps and data presentation issues, unknown or inappropriate sampling and analysis protocols, unknown chain-of-custody procedures; the lack of background or reference samples, the lack of analyses measuring concentrations of toxic chemicals to inform health risk evaluations; the lack of a certified laboratory to perform analyses; the lack of a certified competent individual to approve, monitor and interpret the sampling plan and results obtained. As a result, data quality is unknown, and the data are potentially unreliable and inadequate for supporting the data interpretations needed to evaluate the building condition and its suitability for occupancy. In addition, the data do not appear to have been consolidated in a coherent manner, subjected to appropriate QA, or interpreted and analyzed appropriately. Given these many flaws and deficiencies, the conclusion drawn by FBS utilizing these data that widespread and serious contamination by fire-related combustion residues is specious.

6 Reassessment of the FBS sampling data

To interpret the sampling data, a consolidated data base was assembled; sampling results were interpreted with respect to the likelihood of fire-related combustion residue; and data were presented in tabular and graphical forms to aid interpretation. While most of the flaws pertaining to sampling and analysis noted in the prior section cannot be resolved, this section uses the FBS data to see what the data indicated.

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41 FBS, Oct. 5, 2020, ibid. p. 50 asserts: "I agree "there are no health-based standards or exposure limits", therefore these combustion byproducts from the fire must be removed. Several studies cited in this report [See Figures 48-50 below and Addendum B] discuss the health risks associated with exposure to certain size combustion byproducts. FBS sampled specifically for these combustion byproducts consistent with the fire and the design of the complex. particulates based on micron sizes under 10. [See Figure 48 below] In my opinion, and in consultation with Baxter and Carlson, the particulates we found are a health risk and must be removed." Emphasis added. In addition to conflating the potential for hazard and likely risk, this statement and the EPA graphic in the document refers to $PM_{2.5}$ emissions during the active fire phase, which is irrelevant.

p.51 continues: "Soot is a general term that refers to the black, impure carbon particles resulting from the incomplete combustion of a hydrocarbon. It is more properly restricted to the product of the gas-phase combustion process but is commonly extended to include the residual pyrolyzed fuel particles such as cenospheres, charred wood, petroleum coke, etc. that may become airborne during pyrolysis and which are more properly identified as cokes or chars. The gas-phase soots contain polycyclic aromatic hydrocarbons (PAHs). The PAHs in soot are known mutagens and probable human carcinogens. Soot is in the general category of airborne particulate matter, and as such is considered hazardous to the lungs and general health. Soot is classified as a "Known Human Carcinogen" by the International Agency for Research on Cancer" (IARC). Emphasis added.

On p.42: "Among hydrocarbons produced by the fire and embedded in the combustion byproducts, the poly aromatic hydrocarbons (PAHs) are the main carcinogenic compounds in the soot. Below is a diagram that outlines the issues related to these PAH's." Emphasis added. The report then highlights a diagram of showing biological pathways.

On p. 56, FBS asserts: "In my opinion, as there is not an acceptable level for exposure, the combustion byproducts from the fire found in this building should be removed. Emphasis added.

6.1 Generation of a consolidated database

Despite the issues discussed in Section 5, a consolidated database containing the FBS data was assembled and analyzed. Considerable effort was taken to clean up and correct data locations and other details, where possible, based on close examination of custody forms and the laboratory analytical reports.

6.2 Likelihood of combustion residues

The quality and interpretation of indoor and environmental data is affected by many factors. As suggested in Section 5, these include:

- Inadvertent contamination of samples during sampling, sample transport and/or sample storage. Contamination can be minimized by following best practices and standard operating procedures. For the Metropolitan, many issues are present, e.g., there is no record of blanks that would help document such contamination.

- Uncertainty and errors in laboratory determinations. Visual estimates of combustion residues are highly inaccurate (factor of two) when particle coverage is below 10% and count estimates can be affected by many factors, e.g., morphological heterogeneity.[42] For this and other reasons, laboratories flag questionable data, determine and specify precision, detection and quantification limits, and utilize other means to document data quality and aid interpretation.

- Significance levels to document measurements elevated above normal levels. Numerous sources emit combustion-related particles that are found on essentially all surfaces, and thus sampling results must be compared to reference levels. Soot and PAHs are ubiquitous, for example, arising from countless everyday activities, both indoors and outdoors. Sampling at the Metropolitan included few if any background samples or comparisons (Section 5.2.3).

Data interpretations must account for these realities and use approaches that recognize and minimize *false positives*, called *phantom risks*. For the Metropolitan, this means declaring the presence of fire-related combustion residues and health risks when in fact this is not true and only normal levels of combustion residues are present. A simple, effective and widely used approach is to classify sampling results as having *low, moderate or high likelihood* of showing fire-related combustion residues, based on the entirety of the evidence and accounting for the sampling, laboratory and environmental factors mentioned. It is customary to base classification on the proportion or relatively percentage of different components, called a *ratio analysis*, e.g., the percentage of identified fire residue particles of the total biological and inorganic particles measured. Percentages exceeding approximately 5% indicate an increasing probability of fire residue contamination; percentages above approximately 10% provide stronger evidence.[43 44 45]

Table 3 consolidates several guidelines and expresses conditions for moderate and high likelihood of combustion residues. Ideally, an assessment of moderate to high likelihood of impact would also utilize a *loading or concentration analysis*, since a sufficient number or concentration of particles, loading, or surface concentration

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[42] Kovar, Brad, Russ Crutcher, Heidie Bettes. Wildfire Smoke Exposure: a Comparative Study between Two Analytical Approaches; Particle Assemblage Analysis and Soot, Char and Ash Analysis. https://www.safeguardenviro.com/wp-content/uploads/Wildfire-Smoke-Exposure-a-Comparative-Study-between-Two-Analytical-Approaches-Particle-Assemblage-Analysis-and-Soot-Char-and-Ash-Analysis.pdf

[43] Delia, A, D. Baxter, The ABCs of Wildfire Residue Contamination Testing, *The Synergist*, 2017.

[44] Millette, James R., William Turner Jr., Whitney B. Hill, Pronda Few, J. Philip Kyle. Microscopic Investigation of Outdoor "Sooty" Surface Problems, *Environmental Forensics*, 8:1-2, 37-51, 2007.

[45] Alcaraz, X., Wildfire Residues Assessment and Restoration – A Case Study of the 2017 NorCal Fires, BSI, March 7, 2019.

is necessary to be meaningful from a health perspective (Section 7.3). Particle counts (as can be inferred), loadings, or concentrations were not provided by FBS, thus a loading/concentration criterion was not applied. Nevertheless, the use of the ratio analysis and the interpretation in Table 3 provide a consistent and evidence-based approach to interpret the sampling results.

Table 4. Classification of likelihood of combustion residues. Interpretation based in part on Sonoma County risk management approach in Alcaraz (2019).

Density of Identified Combustion-Related Residues	Likelihood of fire-related Combustion Residues	Interpretation
ND, Trace, 2%	Normal	Typical of recently cleaned surfaces and/or building surfaces w ith minimal or no combustion residues detected.
3% - 4%	Low	Minor presence of combustion residues detected which may be from various sources.
5% - 10%	Moderate	Moderate presence of combustion residues detected beyond normal conditions.
>10%	High	High presence of combustion residues detected beyond normal conditions.

Each sample was reviewed according to the criteria in Table 3 and classified as having normal, low, moderate or high likelihood of combustion residues. To be conservative, the highest value among soot (or black carbon), char and ash determinations was utilized. In the few cases were results where expressed as a range, the range limits were averaged, e.g., a range of 5-15% was considered >10%. For a few samples, data considered likely to have quantitation errors or not indicate fire-related combustion residues were flagged to have low confidence. The evaluation emphasized moderate and high likelihood samples, and considered potential sampling and analysis errors, sample type (air or tape), and sample locations (occupied spaces, building cavities, etc.) as could be determined from the available documentation. Classification of a sample as moderate or high likelihood of combustion residues does <u>not</u> indicate moderate or high health risk, but only the source of particles. Health risks must include consideration of the chemicals, concentrations, exposures and toxicity (Section 7).

6.2.1 Assessment and mapping of FBS data

Table 5 summarizes the number of samples collected by FBS and analyzed by Carlson, representing 14 sampling events and 451 samples. These were grouped by sample location, degree of confidence, and sample location. Low confidence samples had quantitation errors or questions indicated by NG Carlson (sometimes found in the notes on the micrographs), or were air samples collected in kitchens in occupied or previously occupied units with high likelihood of reflecting cooking-related soot. Tables 6 and 7 list all samples, sorted by location and date, which had moderate and high likelihood, respectively. The 20 samples analyzed by EMSL had two such samples (Table 2).

Overall, 40 of the 451 samples had measurement determinations that initially placed them in the high likelihood classification of representing combustion residues. However, 9 of these samples were considered low confidence, and 16 were collected in locations outside the residual units (e.g., parking area, hallways, including a number of areas that could not be determined). Of the remaining samples, 7 tape samples suggested 7 units (1 each on floors 2 and 3, and 5 on floor 4) that provided high likelihood of combustion residues in living spaces; these were found in localized areas on floors 2, 3 and 4. Several of these samples were borderline "high", appear to have

been collected on interior surfaces completed well after the fire, or have other anomalies. These are mapped and discussed in detail next. Overall, a small percentage of samples had a high likelihood of combustion residues.

Table 5. Number of samples collected by FBS and analyzed by Carlson. Grouped by sample type, whether sample was collected inside a housing unit, whether sample had moderate or high likelihood of representing fire-related combustion residues, whether quantitation and identification was likely to reflect fire-related combustion residues, and whether sample was collected in the occupied space (non-structural area).

			Moderate Likelihood				High Likelihood			
Sample Type	Samples Collected	Samples Collected Insid Units	Any	OK Confidence	OK Confidence, Inside Unit	OK Confidence, Inside Unit, Occupied Space	Any	OK Confidence	OK Confidence, Inside Unit	OK Confidence, Inside Unit, Occupied Space
Air	198	137	19	17	6	6	17	11	5	4
Tape	223	170	14	14	9	7	23	20	10	7
Bulk	30	22	2	2	2	1	0	0	0	0
Total	451	329	35	33	17	14	40	31	15	11

Table 6. Samples analyzed by NG Carlson with moderate likelihood of combustion residues.

Date	Inside Unit	Type	Vol	ID-Carlson	Description	Trace density	Char	Soot	Carbon Black	Carbon black/soot	Paint	Notes	Additional notes
5/8/20	219	Tape	-	10	Unit 219 – Bedroom 2 – Door Trim		-	5-10	-	-	-		
5/8/20	232	Air	75 L	25	Unit 232 – Living Room – Ambient (75 liters)		5-7	<1	<1	-	-	.	
5/8/20	232	Tape	-	23	Phase II Unit 232 – Painted Dry Wall near sprinkler		-	5-10	-	-	-		
5/8/20	232	Tape	-	24	Unit 232 Inside Plenum		5 S	1-2	5-10	-	-		
5/8/20	315	Tape	-	17	Unit 315 – Bathroom Closet – Door Trim		1 S	2-3	5-8	-	-		
5/8/20	336	Tape	-	30	Unit 336 – Living Room - window trim		4-6	2-3	3-5	-	-		
5/8/20	344	Tape	-	32	Unit 344 – Master Bed - Window sill		1-2	5-7	7-12	-	-		
1/9/19	408	Air	30 L	8	Phase (Bldg.) #1 Unit 408 kitchen/main	Moderate trace	1	-	-	4-5	-		
5/8/20	417	Air	75 L	18	Unit 417 – Loft – Ambient (75 liters)		10	2	5	-	-		
1/28/20	422	Bulk	-	47B	Unit 422 Bulk closet sheetrock sample		5-10	5-10	-	-	-		
3/25/20	427	Bulk	-	11	Unit 427 Bedroom window sheathing		1-15	-	-	-	-	Spotty for both fungal growth and	
1/9/19	430	Air	30 L	15	Unit 430 kitchen/main area	Moderate trace	6-7	1-2	3-4	-	-		Possible cooking-related residues
1/9/19	435	Air	30 L	17	Unit 435 kitchen/main area	Moderate trace	6-7	1-2	<1	-	-		
7/16/20	437	Air	2 min	27A	Unit 437 Common area	Moderate	7-8	<0.5	-	-	-		
5/8/20	445	Air	75 L	53	Phase III – Unit 445 (75 liters)		5-7	<1	<1	-	-	Asp/Pen ++	Unknown location
5/8/20	446	Tape	-	54	Phase III – Unit 446 – Bedroom window		4-8	1-2	1-3	-	-	Fungal +	
5/8/20	450	Tape	-	57	Phase III – Unit 450 – Master bedroom Light switch box		4-10	1	2-5	-	-	Fungal +++	
5/8/20	451	Tape	-	58	Phase III Unit 451 – Master Bath stud wall		5-10	2-3	-	-	-	Asp/pen like ++	
1/9/19		Air	30 L	16	Corridor outside Unit 430	Moderate trace	8-9	-	<1	-	-		
1/9/19		Air	30 L	18	Corridor outside Unit 434	Light trace	4-5	<0.5	<1	-	-		
4/8/20		Air	2 min	4A	Elevator #1 Floor 4 2 min.	Moderate 792	5-10	-	-	-	-	*The char shape was irregular	
5/8/20		Air	75 L	1	Phase I – Lobby - Ambient (75 liters)	Light trace	4-5	<0.5	<0.5	-	-		
5/8/20		Air	75 L	28	Phase II – North Hallway 3rd floor near		10	2-4	1-2	-	-	Fungal spores Asp/Pen ++	
5/8/20		Air	75 L	49	Phase I – Roof – Inside A/C Unit housing of 118 or 218 (75 liters)		6	<0.5	-	-	-	Fungal ++++	
5/8/20		Air	75 L	72	Phase I Cavity below ground floor – Garage elevator (75 liters)		8-9	2-3	-	-	-		Unknown location
5/8/20		Tape	-	8	2nd Floor Hall – North Painted Drywall		-	3-10	-	-	-		Unknown location
5/8/20		Tape	-	50	Phase II – Roof – A/C cover of Unit 437 or 337		1 S	5-10	-	-	-	Fungal ++++ Spotty soot	
5/8/20		Tape	-	51	Phase III – E-W Hallway – A/C unit by Unit 447		3-8	2-5	-	-	-	Fungal ++++	
5/8/20		Tape	-	63	Phase IV – Mechanical Closet outlet box		5-10	2	-	-	-	Aspergillus ++++	Unknown location
7/16/20		Air	2 min	1A	parking ramp Under tarps storing for 5th floor cabinets	Moderate to heavy	8-10	<1	-	-	-	Cladosporium spp. ++ Epicoccum spp. + Other fungal + Pollen +	
7/16/20		Air	2 min	4A	parking ramp 4th floor storage container #404	Moderate to heavy	8	<0.5	-	-	-	Fungal +	
7/16/20		Air	2 min	7A	parking ramp 4th floor inside storage Unit 466	Moderate	5	<0.5	-	-	-	Fungal +	
7/16/20		Air	2 min	8A	parking ramp Storage Unit 416	Moderate	5	<1	-	-	-	Fungal +	
7/16/20		Air	2 min	16A	parking ramp unit 321	Moderate	7	<0.5	-	-	-	Fungal +	
7/16/20		Tape	-	15T	parking ramp #303 third floor		4-6	<1	-	-	-		

Table 7. Samples analyzed by NG Carlson with high likelihood of combustion residues. Unit indicates sample taken inside unit number shown.

Inside	Date	Inside Unit	Type	Vol	ID-Carlson	Description	Trace density	Char	Soot	Carbon Black	Carbon black/soot	Paint	Notes	Additional notes
Int	5/8/20	137	Tape	-	39	Unit 137 – Interior Wall Framing		10-12	-	-	-	-	Very heavy debris	
Int	5/8/20	219	Air	75 L	9	Unit 219 – Bedroom 1 – Ambient (75 liters)	Moderate Trace	12-15	1-2	1	-	-		
Int	5/8/20	219	Tape	-	12	Unit 219 – Bedroom 3 – Painted Drywall		-	30-40	-	-	-		
Int	8/25/20	303	Tape	-	24T	Unit 303 Mechanical room		-	20-30	-	-	-	Particles similar to soot	Possible identification error
Int	1/28/20	307	Tape	-	69T	Unit 307 Bedroom 2 N. wall existing		-	30-40	-	-	-	Could be paint but particles are not all spheres	Possible identification error
Int	5/8/20	315	Air	75 L	15	Phase I – Unit 315 – Bedroom – Ambient (75 liters)	Light Trace	12-15	2-3	4-6	-	-		
Int	5/8/20	336	Air	75 L	29	Unit 336 – kitchen Island – Ambient (75 liters)	Very Heavy	45-50	5-8	1-2	-	-		
Int	5/8/20	344	Air	75 L	31	Phase II – Unit 344 – Bedroom 2 – Ambient (75 liters)	Very Heavy	25	10	-	-	-	Numbers are estimated as particle trace was very heavy	
Int	5/8/20	344	Tape	-	33	Unit 344 – Guest Closet - Baseboard		1-2	10-15	25-30	-	-		
Int	1/9/19	416	Air	30 L	6	Phase (Bldg.) #1 Unit 416 kitchen/main area	Moderate to Heavy Trace	-	-	-	50+	-	The carbon black/soot particles had characteristics of both soot and carbon black- loose sphere clusters of soot- like particles.	Possible cooking-related residues
Int	1/9/19	422	Air	30 L	10	Unit 422 kitchen/main area	Moderate to Heavy Trace	<1	-	-	50+	-		Possible cooking-related residues
Int	1/9/19	423	Air	30 L	11	Unit 423 kitchen/main area	Moderate to Heavy Trace	-	-	-	50+	-		Possible cooking-related residues
Int	1/9/19	426	Air	30 L	13	Unit 426 kitchen/main area	Moderate trace	<1	-	-	50+	-		Possible cooking-related residues
Int	1/9/19	428	Air	30 L	14	Unit 428 kitchen/main area	Moderate trace	<1	-	-	14-16	-		Possible cooking-related residues
Int	7/16/20	437	Tape	-	28T	Unit 437 Common area close to utility closet stud		5-15	-	-	-	-	Fungal +	
Int	5/8/20	438	Air	30 L	34	Phase II – Unit 438 – Living Room Circuit Box		3	15-20	-	-	-		
Int	5/8/20	438	Tape	-	35	Unit 438 – Living Room – Painted Dry wall		<1	10-12	1-2	-	-		
Int	7/16/20	441	Tape	-	19T	Unit 441 Bathroom north stud in nook		40 -50	-	-	-	-		
Int	5/8/20	447	Tape	-	52	Phase III – Unit 447 – Master Bedroom Door header		7-15	2-5	3-5	-	-	Fungal +++	
Int	5/8/20	452	Tape	-	59	Phase III Unit 452 – Living Room Window frame		2-4	1	10-20	-	-	Fungal +	
Int	5/8/20	456	Tape	-	67	Phase IV – Unit 456 – Bathroom Door Frame		15	1-2	-	-	-	Asp/Pen ++++ Alternaria spp. +	
Int	5/8/20	457	Tape	-	66	Phase IV – Unit 457 – sub floor truss in Living room		8-15	1-3	-	-	-	Asp/Pen ++++ Other fungal ++++	
	1/9/19		Air	30 L	7	Phase (Bldg.) #1 corridor in Bldg. #1 outside Unit 416	Moderate to Heavy Trace	<1	-	-	50+	-		
	1/9/19		Air	30 L	12	East corridor outside Unit 424	Moderate trace	-	-	-	50+	-		
	5/8/20		Air	30 L	48	Phase IV – S. Exterior Wall – Exhaust Vent Duct		10-15	-	-	-	-	Pine Pollen	Unknown location
	5/8/20		Tape	-	14	Phase I – Floor 2 Mechanical Room – Painted Drywall		-	30-40	-	-	-		Unknown location
	5/8/20		Tape	-	27	Phase II – North Hallway outside Unit 240 – Wood ceiling joist		10-20	1-2	-	-	-	Heavy Debris	
	5/8/20		Tape	-	42	Phase I – E. Exterior wall – behind siding		-	15-20	-	-	-	.	Unknown location
	5/8/20		Tape	-	46	Phase I – E. Exterior wall – Large vent duct (same as #45)		20-25	1-3	1-3	-	-	Heavy pollen and pine pollen	Unknown location
	5/8/20		Tape	-	47	Phase I – E. Exterior wall – Exhaust vent duct		3-8	1-3	10-20	-	-	Fungal ++ Heavy pollen and pine pollen	Unknown location
	5/8/20		Tape	-	60	Phase III – In-ceiling A/C Duct (top) outside Unit 445		8-12	1-2	2-5	-	-	Fungal +++	
	5/8/20		Tape	-	65	Phase IV – Top of A/C Unit in N-S Hallway		1-3	15-20	-	-	-	Asp/Pen ++++ Stachybotrys + Other fungal growth	Micrograph says: very spotty on this sample; Unknown location
	7/16/20		Air	2 min	11A	parking ramp 401-433 appliance storage	Heavy	40-50	<1	-	-	-	Fungal + Char and other char-like particles	
	7/16/20		Air	2 min	14A	parking ramp #303 third floor	Heavy	40-50	1-2	-	-	-	Fungal +	
	7/16/20		Air	2 min	1A	parking Outdoor air sample	Heavy	10-15	<1	-	-	-	Other fungal +	
	7/16/20		Tape	-	2T	parking ramp #119 pile on 5th floor		20-25	1-2	-	-	-	Pollen ++	Unknown location
	7/16/20		Tape	-	13T	parking ramp Open air garage sinks		15-20	1-2	-	-	-		
	7/16/20		Tape	-	3T	NW corner hallway North of Unit 144 Face of stud		5-15	<1	-	-	-	Fungal +	
	7/16/20		Tape	-	15T	Corridor outside Unit 442 OSB sheathing facing parking ramp		20-50	-	-	-	-		
	8/27/20		Air	2 min	P	Corridor Fire equipment area by Unit 236	Heavy	20-25	-	-	-	-	Fungal ++ Sample looks like outside air Atypical char particles	Stated to be atypical char; uncertain; no micrograph; discounted

To aid interpretation, samples analyzed by NG Carlson Associates that indicated moderate or high likelihood of combustion residues in Metropolitan housing units were mapped by floor level and unit (Figures 6 to 9). Each map shows three quantities: the number of samples in a housing unit with moderate likelihood of combustion residues (orange background); the number of samples in a unit with high likelihood of combustion residues (red background), and the total number of samples collected in the housing unit (blue background). This analysis includes 332 samples analyzed by Carlson (including air, tape or bulk) that were collected in units that could be identified. One sample, apparently mistakenly labeled as "unit 38," could not be located based on the available documentation. Samples taken in the parking area or in corridors were not included.

- Floor 1: Figure 6 shows that of the 48 samples collected, 2 samples (4%) indicated high likelihood of combustion residues. These were both tape samples on framing in Unit 137 and "hallway north of 144".
- Floor 2: Figure 7 shows that of the 55 samples collected, 4 (7%) and 2 (4%) of the samples indicated medium and high likelihood, respectively, of combustion residues. Three of the moderate likelihood samples were identified in Unit 232 (one inside a plenum); the high likelihood samples (tape and air) were identified in Unit 219, which is flagged with a star in the figure. Designating Unit 219 as showing high likelihood of combustion residues due to soot detected on a painted drywall in a bedroom is uncertain given that this unit had been occupied and that drywall removal in this building had started months earlier, thus, the soot detected appears likely to reflect resuspended material. The lack of documentation regarding the sample location and other matters makes this determination uncertain, but likely not to be representative of conditions in this unit or building, which is reinforced since no other samples in Phase 1-3 buildings were shown to have high likelihood samples (after correcting for likely sampling errors).

  Floor 3: Figure 8 shows that of the 81 samples collected, 4 (5%) and 6 (7%) indicated moderate and high likelihood, respectively, of combustion residues. In three of the "high" samples, laboratory notes raise questions regarding identification (i.e., possible paint particles rather than fire-related residues in Unit 307 (tape sample in a bedroom); "soot like" characteristics for a tape sample in the Unit 303 "mechanical room"; and uncertain counts in 344, a 75 L air sample in a bedroom. A medium likelihood (only) air sample was indicated in Unit 342. The remaining high (and in one case a moderate) likelihood samples were found in three units (315, 336, 344). In Unit 315, a 75 L air sample collected in a bedroom showed a high likelihood of combustion residues, however, air samples likely reflect contemporary sources of particles, e.g., cooking, outdoor pollutants, etc., and not fire-related combustion residues unless materials were disturbed. Further, this is the only sample of 8 samples were collected in Unit 315 that showed high likelihood of combustion residues; a tape sample in a bathroom closet trim in Unit 315 showed moderate likelihood of combustion residues; these levels were borderline (4-6). In Unit 336, the "high" sample was a 75 L air were collected on a kitchen island that may be cooking residues. In Unit 344, in addition to the "high" air sample noted above, a tape sample on the "master bed window sill" showed a moderate likelihood of combustion residues, and a "high" tape sample was collected on a "guest closet baseboard." The high tape sample was collected on May 8, 2020 on a baseboard, which would have been constructed after the fire, and thus this sample does not appear to represent fire-related combustion residues.
- Floor 4: Figure 9 shows that of the 147 samples collected, 11 (8%) and 13 (7.5%) samples indicated moderate and high likelihood, respectively, of combustion residues. High likelihood samples were shown in in 11 housing units. Six of the "high" samples were air samples, five of which were likely to reflect cooking-related residues, especially as carbon black and minimal char was detected and these units had been previously occupied. This applies to Units 416, 422, 423, 426 and 428. The sixth "high" air sample was in a "circuit box" in Unit 438 (an unusual place to collect a 30 L air sample, which would be likely to disturb the space). Of the "high" tape samples, two were collected on studs or trusses and not inhabited spaces (Units 441, 457). A "high" but marginal (5-15) tape sample was collected in Unit 437 ("common area close to a utility closet stud"). "High" tape samples were collected in Unit 438 ("painted dry wall"), 447 ("door header"), 452 ("window frame"), and 456 ("door frame"). Sampling in unit 438 on the painted dry wall surface (collected on May 8, 2020), indicates that the sample was collected on a building surface

installed well after the fire, and thus does not reflect fire-related combustion materials. Assuming the other tape samples were collected on surfaces exposed during or shortly after the fire, five units had high likelihood of combustion residues (shown with stars in Figure 8); three of these units are in the Phase 6 building.

Figure 6. 1st floor plan of Metropolitan showing FBS results analyzed by NG Carlson with medium (yellow) and high (red) likelihood of combustion residues in Metropolitan apartments. Number of samples collected in each unit shown in blue.

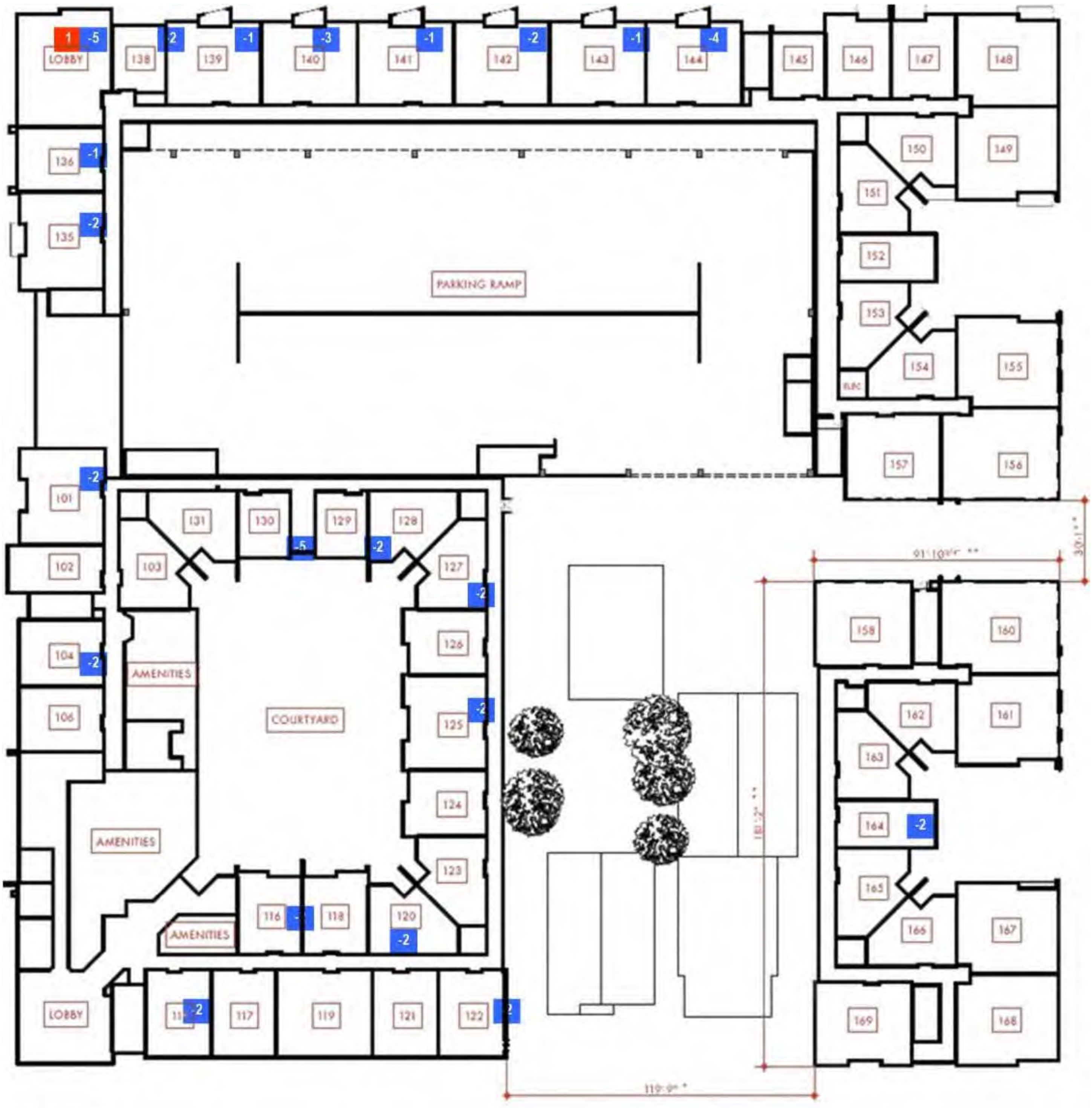

Figure 7. 2nd floor plan of Metropolitan showing FBS results analyzed by NG Carlson with medium (yellow) and high (red) likelihood of combustion residues in Metropolitan apartments. Number of samples collected in each unit shown in blue. Star indicates unit where sampling suggests high probability of combustion residues, although this result appears uncertain and not representative.

Figure 8. 3rd floor plan of Metropolitan showing FBS results analyzed by NG Carlson with medium (yellow) and high (red) likelihood of combustion residues in Metropolitan apartments. Number of samples collected in each unit shown in blue. Star indicates unit where sampling suggests high probability of combustion residues.

Figure 9. 4th floor plan of Metropolitan showing FBS results analyzed by NG Carlson with medium (yellow) and high (red) likelihood of combustion residues in Metropolitan apartments. Number of samples collected in each unit shown in blue. Star indicates unit where sampling suggests high probability of combustion residues.

6.3 Summary

Considering all of the samples collected by FBS and accounting for data quality issues, background or reference levels, and other factors normally considered in assessing environmental sampling results, a low percentage of samples showed either moderate or high likelihood of fire-related combustion residues in occupied spaces of the Metropolitan. Most samples showed normal or background levels. Most (6 of 7) of the units considered to have high likelihood of fire-related combustion residues in occupied spaces were found in or adjacent to the Phase 5 building, and on upper floors. The high likelihood sample in Unit 219 is anomalous and likely reflects resuspended material that is not representative. This analysis shows limited distribution of fire-related combustion residues in the Metropolitan: the vast majority of samples were negative. The identification of fire combustion residues in these locations is fully consistent with the meteorological data and analysis in Section 4. While a small number of samples showed combustion residues, this does not imply a health risks, as discussed next.

7 Health risks

Fire-related emissions and combustion residues likely to affect indoor environments and cause adverse health effects will have one or more of the following characteristics: high emission rates, high toxicity, environmental persistence, the potential to participate in sink/source relationships, and ability to expose individuals by a completed *source-to-receptor exposure pathway* involving human uptake, e.g., by inhalation. This section reviews the composition of emissions from fires, the toxicity of specific chemicals, and exposures in buildings, and determination of health risks.

7.1 Composition of fire-related emissions and combustion residues

7.1.1 Structure fires

The potential that combustion residues cause adverse health effects starts with the chemical and physical nature of fire-related emissions. The literature regarding the chemical composition of emissions from structure fires is limited and difficult to generalize since emissions depend on many factors, e.g., the burning rate, the material being burned, and fire conditions.[46] Environmental health concerns from urban fires during the fire and their aftermath focus on particulate matter, irritant gases (hydrogen chloride, sulfur dioxide, hydrogen fluoride, hydrogen bromide, nitrogen oxides, and ammonia), asphyxiant gases (carbon monoxide, hydrogen cyanide), organic toxicants (formaldehyde, formalin, PAHs, dioxins), ozone, and combustion-produced free radicals.[47] Depending on the material burned in structure fires, ash and debris produced by the combustion of building materials can contain lead, arsenic, hexavalent chromium, PAHs, dioxins, pesticides, and cresols.[48] Many fire-related emissions and combustion residues, including PAHs, are general indicators of incomplete combustion, and these compounds have numerous indoor and outdoor sources, e.g., cigarette smoke, asphalt pavement sealers, cooking (e.g., barbequing, frying and grilling), candles, gas combustion appliances, vehicle exhaust (especially diesel engines), leaf burning, and industry.[49]

Emission factors provide quantitative descriptions of the composition and emission rates of chemical including toxic compounds. The literature pertaining to emission factors from structure or urban fires is limited. Chemical

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[46] Stec, A, R. Hull, Fire Toxicity, Woodhead Pub, 2010.

[47] AIHA 2018, ibid

[48] Delia, A, D Baxter, The ABCs of Wildfire Residue Contamination Testing, *The Synergist*, 2017

[49] World Health Organization, Polycyclic aromatic hydrocarbons Guidelines for Indoor Air Quality: Selected Pollutants. 2010.

analyses conducted on a subset of samples collected at the Metropolitan were limited to elemental analyses intended to aid particle identification, and did not provide information pertaining to toxicity. For this reason, emissions information from better characterized wild land fires is reviewed.

7.1.2 Wild land fires

The literature pertaining to emissions from wild land fires is relatively large and growing. There are similarities and differences between the composition of structure and wild land fire emissions. The following underscores some of the characteristics of fires and present emission factors that describe the levels of toxic compounds, specifically PAHs, which is relevant to structure fires.

The composition of forest fire emissions has been reviewed by Urbanski,[50] Urbanski,[51] Yokelson, [52] Battye (for US EPA),[53] Durán,[54] and Akagi.[55] Conditions at such fires are complex and time varying, and include combinations of different thermal degradation processes (distillation, pyrolysis, char oxidation, flaming oxidation), a variety of material burned (wood types, soils, etc.), and a range of environmental conditions; these and other factors produces a wide range of gaseous and particulate emissions. Urbanksi (2009) notes that the major emissions include CO_2, CO, $PM_{2.5}$, and CH_4; other emissions include alkanes, alkenes, alkynes, aromatic hydrocarbons, aldehydes, ketones, alcohols (methanol), acids (formic and acetic), and furans. Oxygenated VOC emissions are dominated by methanol, acetic acid, formic acid, and formaldehyde. Additional emissions include PAHs, metals, chlorinated VOCs, and oxygenated and nitrogenated PAHs.

Emission factors from forest fires and other types of fires have been determined for a number of pollutants that allow estimates of both the amount and composition of fire emissions, including various gases, particulate matter, and PAHs. Benzo(a)pyrene (BaP) and certain other PAHs represent toxic and relatively persistent chemicals emitted in fires that can undergo off-gassing (volatilization) after being deposited on building surfaces as combustion residues. Among the PAH compounds, benzo(a)pyrene (BaP) is the most toxic chemical and one of the most abundant in combustion emissions. BaP constitutes from approximately 0.004 to 0.04% (by weight) in

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[50] Urbanski, Shawn P., Wei Min Hao and Steve Baker, "Chemical Composition of Wildland Fire Emissions," *Developments in Environmental Science*, Vol 8, A. Bytnerowicz ed. Elsevier, 2009. 31.p. Accessed https://www.nifc.gov/smoke/documents/Chem_Comp_Wildland_Fire_Emissions.pdf

[51] Urbanski, Shawn, Wildland fire emissions, carbon, and climate: Emission factors, *Forest Ecology and Management*, 317 (2014) 51–60, 2013.

[52] Yokelson, R.J., Burling, I.R., Gilman, J.B., Warneke, C., Stockwell, C.E., de Gouw, J., Akagi, S.K., Urbanski, S.P., Veres, P., Roberts, J.M., Kuster, W.C., Reardon, J., Griffith, D.W.T., Johnson, T.J., Hosseini, S., Miller, J.W., Cocker III, D.R., Jung, H., Weise, D.R., 2013. Coupling field and laboratory measurements to estimate the emission factors of identified and unidentified trace gases for prescribed fires. *Atmos. Chem. Phys*. 13, 89–116. Also see supplemental materials.

[53] Battye, William, Rebecca Battye, "Development of Emissions Inventory Methods for Wildland Fire, EC/R Inc. Feb. 2002. https://www3.epa.gov/ttnchie1/ap42/ch13/related/firerept.pdf

[54] Durán, Sandra. Evidence Review: Wildfire smoke and public health risk, British Columbia (Canada) Center for Disease Control. March 31, 2014.

[55] Akagi, S. K; Yokelson, R. J; Wiedinmyer, C; Alvarado, M. J; Reid, J. S; et al. Emission factors for open and domestic biomass burning for use in atmospheric models. *Atmospheric Chemistry and Physics*;.11, 9, 2011: 4039.

particles emitted from forest fires for particles up to about 10 μm diameter, a size range that contains most of the PAHs.[56] [57]

7.2 Toxicity and health risks of combustion residues

The toxicity of exposure to many fire-related pollutants, such as particulate matter, carbon monoxide, and many other pollutants is well known, and there is a voluminous literature on many pollutants. This applies to direct inhalation exposure, typically during the active burning phase, which is most relevant to fire fighters, other first responders, and general populations that may be exposed. These are mostly acute or short-lived exposures (minutes to a few days), and generally not relevant to deposited or settled combustion residues.

Fire-related emissions and combustion residues concerns raised at the Metropolitan include PAHs. As noted earlier, sources of PAHs are numerous and exposure is ubiquitous. PAHs are products of incomplete combustion, and common sources include tobacco smoke, wood smoke, fireplaces, cooking, candles, combustion of natural gas, many industrial process, traffic and engine exhaust. PAHs comprise a large and diverse set of compounds. Some PAHs are toxic and thus of health concern. PAHs also serve as *indicators* of other compounds that might be present and associated with fire-related emissions or combustion residues that may not be measured. This indicator role is important since it is not feasible (or possible) to measure each pollutant that might be present. Some PAH compounds are persistent, some may off-gas, and some are toxic at low concentrations. The major health concern with PAHs is *chronic exposure* (long term) that can increase the risk of cancer. Two PAHs (benz[a]anthracene and benzo[a]pyrene) are considered as probable human carcinogens, and four other PAHs (benzo[b]fluoranthene, benzo[j]fluoranthene, benzo[k]fluoranthene, and indeno[1,2,3-c,d]pyrene) as possible carcinogens.[58,59]

Reference levels have been determined for many toxic chemicals, based on toxicological, epidemiological and modeled data, and represent concentrations that individuals may be exposed to that present a minimal, and generally negligible, likelihood of an adverse health outcome. Information pertaining to PAHs for which US Environmental Protection Agency (among others) has recommended guidelines is shown in Table 8. These are taken from the comprehensive set of reference levels called the *Regional Screening Levels* (RSLs). While initially developed for application at Superfund sites, RSLs represent updated and consistent comparison values for residential air (also commercial/industrial exposures to soil, air, and drinking water). For a given chemical, the RSL is a concentration that corresponds to fixed a level of risk, either a one-in-one million for cancer risk, which is defined as developing a tumor over an individual's lifetime due to exposure, or a noncarcinogenic hazard quotient of 1, which is the level at which no adverse non-cancer effects are expected from acute or chronic

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56 The proportion of PAHs emitted from a fire was calculated as the ratio of the emission factors (EF) for PAHs and $PM_{2.5}$. The PAH considered was benzo(a)pyrene (BaP), considered the most toxic PAH. The EF for BaP ranges from 0.004 mg/kg wood burned (Battye, 2002) to 4.9 mg/kg (Kakreka average in WHO, 2011). The EF for $PM_{2.5}$ ranges from 7 to 15 g/kg of wood burned, depending on the forest type (Akagi et al. 2011); the average 11 g/kg was used. The BaP fraction in small particles is thus 0.0004 to 0.045% of $PM_{2.5}$ by weight, i.e., on the order of 1 part in 2200 to 1 part in 27000. This estimate applies to BaP and is an order of magnitude estimate given the many factors that can affect emissions. Very similar estimates are obtained in the citation in the next footnote.

57 A separate estimate from a different source for the BaP percentage in wood combustion is 0.0285% in PM_{10}. From Khalili, Asrin R., Peter A. Schefft, Thomas M. Holsenpah. Source fingerprints for coke ovens, diesel and gasoline engines, highway tunnels, and wood combustion emissions. *Atmospheric Environment* 29. 4, 533-542, 1995

58 Agency for Toxic Substances and Disease Registry, Public Health Statement for Polycyclic Aromatic Hydrocarbons (PAHs), 1995. https://www.atsdr.cdc.gov/PHS/PHS.asp?id=120&tid=25. Accessed 5-20-19.

59 WHO, Chapter 6, Polycyclic aromatic hydrocarbons: Guidelines for Indoor Air Quality: Selected Pollutants, Geneva: World Health Organization; 2010. ISBN-13: 978-92-890-0213-4. https://www.ncbi.nlm.nih.gov/books/NBK138705/

exposures.[60] For many chemicals, the RSLs are similar or identical to other screening levels used by other agencies,[61] although a number of states consider higher risks to be acceptable, e.g., 1 in 100,000, which would have the effect of multiplying the screening level in the table below by 10. The key factor in this table is the Screening Level for benzo(a)pyrene, the most toxic PAH, which has the lowest screening level, 0.002 μg/m^3. Maintaining average levels below this value is considered safe.

There can be considerable uncertainty in setting reference levels, and differences of approximately a factor of 2 to 10 in reference levels are not unexpected and may not be meaningful. Reference levels are designed to be conservative and health protective, and they incorporate uncertainty using safety factors and confidence intervals. Thus, even concentrations that approach or exceed risk-based screening levels are not necessarily harmful or unsafe.

Table 8. Toxicity information for PAHs that have risk-based health protective levels. The screening level is the recommended concentration limit from US EPA for residential exposure using 1 in a million cancer risk and hazard ratio of 1.[62] WOE is weight of evidence classification.

		Non-cancer Effects		Cancer Effects				
Name	**Screening Level** (ug/m3)	**Effects**	**Ref**	**EPA WOE**	**IARC WOE**	**Risk Factor** (m3/ug)	**Effects**	**Reference**
Naphthalene	0.083	Methemoglobinemia, chronic nasal inflammation, olfactory epithelial metaplasia, and respiratory epithelial hyperplasia.	OEHHA (2005)	C	2B	3.4E-05	Respiratory epithelial adenoma, olfactory epithelial neuroblastoma	OEHHA (2005)
Chrysene	1.700		IRIS (1990f)	B2	2B	6.0E-07	Liver tumors, malignant lymphoma, hepatic tumors and lung tumors	IRIS (1990f)
Benzo(a)anthracene	0.017		IRIS (1990g)	B2	2B	6.0E-05	Pulmonary adenoma, hepatoma and liver adenomas	IRIS (1990g)
Benzo[b]fluoranthene	0.017		IRIS (1990h)	B2	2B	6.0E-05	Liver adenomas and hepatomas, lung adenomas	IRIS (1990h)
Benzo[k]fluoranthene	0.170		IRIS (1990i)	B2	2B	6.0E-06	Hepatic adenomas and hepatomas, lung adenomas	IRIS (1990i)
Benzo[a]pyrene	0.002	Developmental, immunological and reproductive effects	IRIS (2017)	CH	1	6.0E-04	Forestomach, liver, oral cavity, duodenum, and auditory canal tumors	IRIS (2017)
Indeno[1,2,3-cd]pyrene	0.017			B2	2B	6.0E-05	Tumors and gene mutation	IRIS (1990j)
Dibenz[a,h]anthracene	0.002			B2	2A	6.0E-04	Carcinomas, DNA damage and gene mutations	IRIS (1990k)
Dibenzo[a,e]pyrene	0.003			-	3	6.0E-04	Carcinoma, papilloma, sarcoma, skin neoplasms	NCBI (2020c)

60 United States Environmental Protection Agency (EPA) Regional Screening Levels (RSLs) 2018 EPA RSL noncarcinogenic values. https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables

61 For example, many RSLs are similar or identical to levels in EPA's Risk Information System (https://www.epa.gov/iris), and also similar or identical to levels for Michigan's risk screening levels (http://www.deq.state.mi.us/itslirsl/results.asp).

62 The Regional Screening Levels are available at https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables. IRIS is the US EPA Integrated Risk Information System. OEHHA is the California Environmental Protection Agency's Office of Environmental Health Hazard Assessment (OEHHA).

7.3 Exposure and risk

7.3.1 Exposure and risk assessment

Toxic chemicals like PAHs are common or ubiquitous in indoor and outdoor settings and everyday life. However, chemicals found at low levels and those with minimal potential for exposure and human intake (called *dose*) do not pose a health concern. While the old adage *the dose makes the poison* [63] is simplistic, it conveys the importance of quantifying the exposure. *Quantitative risk assessment* is used to allow meaningful assessments of chemical risks and to guide subsequent risk management actions to protect individuals and public health, and to avoid needless actions to address so-called phantom risks.

Quantitative risk assessments and management actions follow well-defined steps to provide objective assessments that are protective of public health. The practice of risk assessment and management include quantification of the likelihood or probability of harm to determine whether a risk is acceptable or requires mitigation. This applies to short-term or *acute* exposures of toxicants causing non-cancer health endpoints like carbon monoxide, which have threshold-limited dose-response relationship. It also applies to long-term or *chronic* exposures of toxicants like PAHs that can cause cancer, and which have a continuous, zero threshold dose-response relationship describing the likelihood of an adverse health impact. For chemicals causing cancer, assessments are mostly based on the likelihood of causing a tumor over the lifetime. Only a very small likelihood is considered to be acceptable for environmental contaminants. These likelihoods are limited to a probability or chance of 1 in 10,000 (10^{-4} risk) to 1 in 1 million (10^{-6} risk).

As a simple and protective approach that follows from the risk levels just above, measured or estimated concentrations are compared to guideline or reference levels. The EPA RSLs (Table 8) are relevant for residential exposure, are protective, relevant to both acute and chronic exposure, and consider both cancer and non-cancer endpoints. Maintaining average levels below the reference level is considered safe for human exposure.

7.3.2 Exposure pathways

Individuals may be exposed to combustion residues if these residues or components thereof make their way into the occupied living spaces and are inhaled. In cases, chemicals may migrate to surfaces, dusts, foods, or other materials that are subsequently ingested. For exposure to represent a health risk, concentrations must exceed reference levels. For carcinogens, concentrations must exceed reference levels on a long-term basis, typically over many years.

Combustion residues that have been deposited or settled in building cavities or other hidden surfaces must have a completed source-receptor pathway, i.e., migrate to occupied living spaces, to exposure individuals. For low volatility chemicals in a building cavities, this migration can only occur in the event of a disturbance, most typically construction activities that open up the wall or other compartment. For semi-volatile chemicals (SVOCs) which include many PAHs, volatilization or off-gassing from building cavities, migration into indoor air, and subsequent deposition on particles or other surfaces is an additional pathway that potentially can expose individuals.

No gaseous or vapor phase sampling was conducted, and no chemical analyses were conducted relevant to off-gassing, thus there is no evidence of off-gassing of combustion residues. Similarly, no surface concentration measurements were made of chemicals like PAHs in the Metropolitan, thus there is no evidence of levels toxic chemicals on surfaces. As mentioned, there are numerous other indoor and outdoor sources of soot and PAHs; these substances are ubiquitous; and the contribution of fire-related combustion residues must account for the

[63] "The dose makes the poison" (Latin: sola dosis facit venenum 'only the dose makes the poison') is an adage intended to indicate a basic principle of toxicology. It is credited to Paracelsus who expressed the classic toxicology maxim "All things are poison, and nothing is without poison; the dosage alone makes it so a thing is not a poison." https://en.wikipedia.org/wiki/The_dose_makes_the_poison.

presence of normal background and environmental levels known to exist in Birmingham and essentially everywhere (Section 5.2.3).

Any off-gassed compounds from combustion residues in building cavities would be at very low airborne concentrations in the Metropolitan for several reasons: the limited extent of fire-related combustion residues in the buildings; the passage of time and normal air change in the building that would tend to degrade and flush out these chemicals from building air; the low to very low volatility of these chemicals, other chemical properties that produce very low emission rates and a tendency for deposition or binding to particles and surfaces with limited, if any vapor-phase fraction; and the limited air flow rates in building cavities that would transport these chemicals into the occupied space prior to redeposition.

The amount of soot needed as fire-related combustion residues in a typical housing unit at the Metropolitan to produce chronic exposures to BaP that would equal to the protective RSL was estimated using conservative and worst-case assumptions and the information pertaining to the Metropolitan's layout.[64] This analysis used a "worst-case" screening level estimate and a mass balance approach. While there are many simplifying assumptions, each goes in the conservative direction, e.g., it is assumed that all BaP in soot volatilizes, that no BaP degrades, that individuals never leave the housing unit, and that all BaP contributes to indoor levels. To achieve the RSL, which is considered a safe exposure, each residence unit must have from 83 to 3038 grams of soot as combustion residues, i.e., from about 3 ounces to 6 lbs. The amount of soot would completely coat some or all walls in each unit. While based on well-founded mass balance principles, this calculation is hypothetical, simplified and approximate. However, <u>the analysis demonstrates the considerable amount of soot needed to produce a health risk from off-gassing and migration from building cavities or other locations under highly</u>

[64] The "worst-case" screening level calculation used a mass balance approach to demonstrate that the quantity of soot needed in each unit to produce the EPA risk-based Regional Screening Level. The assessment assumes the following: Soot contains BaP, the most toxic PAH, at levels from 0.0036 to 0.045% of soot by mass (as discussed previously). An indoor concentration equal to the health protective reference level (0.002 $\mu g/m^3$) is produced by soot volatilization and migration to the living space. All BaP in soot is assumed to be volatilized and migrate to living areas at a constant rate over the exposure period of 10 to 30 years. BaP does not degrade over this period. The volatilized BaP and PAHs are uniformly distributed in the living space. The exposed individual is in the building 24 hours a day for 365 days per year for the exposure period. (In reality, much of the BaP and PAHs would remain bound to surfaces and not migrate; BaP and PAHs could also migrate directly into outdoor air or non-living areas resulting in no exposure; oxidation and degradation would tend to reduce BaP and PAH levels over time; and individual will leave the Metropolitan for substantial portions of the day.) It is also assumed that the apartment volume averages 280 m^3, based on an area of 1100 SF and 9 ft ceiling height. (This is estimated from the architectural plan and is a non-critical assumption.) The air change rate for the apartment is assumed to average 0.75 hr^{-1}. (Most US homes have air change rates that range from about 0.5 to 1.0 hr^{-1}). Volatilized PAH are removed from the living space by the air flow determined by air change rate. With these assumptions, the amount of soot required in <u>each</u> unit to reach a chronic exposure of BaP at the reference level ranges from 83 to 3038 grams, i.e., from about 3 ounces to 6 lbs.

Expressed differently, if this soot resulted from air infiltration and particle penetration from an exterior wall (8.4 m^2 in area using the stated dimensions) where it was first deposited and the soot density was 1.5 g/cc, then the entire wall would be 100% coated with a thickness from about 10 to 400 μm of soot (depending on the assumptions above); if the soot came in as particles 1 μm in diameter was uniformly deposited, this would represent roughly 10 to 400 layers of soot particles, e.g., many layers of soot particles would cover the entire wall. While based on mass balance, these are hypothetical, simplified and approximate calculations intended only to demonstrate that the amount of soot needed to produce a health risk from off-gassing and migration from building cavities or other locations under highly conservative conditions.

The level of contamination from this calculation would be plainly visible. The FBS report (Oct. 5, 2020) asserts (p. 54): "None of the combustion byproducts sampled by FBS could be seen by the naked eye and that is what makes it so dangerous." This may be referring to individual soot particles.

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conservative conditions, which far exceeds the actual amount of combustion residues in the Metropolitan, thus off-gassing is extremely unlikely to yield unsafe concentrations.

7.4 Concentrations of PAH and other compounds will decrease with time

PAHs and other organic chemicals degrade over time due to chemical reactions and chemical degradation. These reactions are facilitated by other chemicals, e.g., hydroxyl radicals and ozone, as well higher temperature. The lifetime of PAHs and other SVOCs in air and on indoor surfaces exposed to sunlight, ozone and hydroxyl radicals can be shortened considerably. Considering BaP, the most toxic PAH, the atmospheric lifetime in a typical urban atmosphere is only 20 minutes; a few or days hours might be expected in most atmospheres.[65] Reaction and degradation will lower emission rates from deposited or settled chemicals like PAHs, and will also lower concentrations of any fraction of the chemical that has volatilized, become airborne and migrated into the living space.

7.5 Literature evidence of exposure

The health effects of exposure to combustion residues like PAHs that may have infiltrated into a structure following a wildfire have not been well characterized in the literature.[66] However, a recent (2019) and comprehensive study of wild land and urban fringe fire-related residues in 64 homes exposed to the very large 2016 wild land-urban interface fires at Fort McMurray, Alberta Canada showed no evidence that forest fire ash remained in household 14 months after the fire, and overall house dust pollutant concentrations were equal or lower than in other locations unaffected by wildfires, suggesting negligible potential for long term effects in buildings from fire-related combustion residues.[67]

7.6 Omissions and flaws by FBS

The visual and/or microscopic detection of fire-related combustion residues in building cavities and interstitial spaces, or in building air and surfaces does not represent a health risk. Risk depends on establishing the presence of a toxic substance where individuals can be exposed, e.g., air inhaled by an individual, and determining that concentrations, exposure periods and uptake of the chemical are sufficiently high to obtain a meaning dose. FBS's statements regarding the detection of soot, ash and/or char provide little if any information regarding the physical or chemical composition or concentration of these materials. FBS presents no evidence regarding fire-related combustion residues that would affect air quality and exposure building occupants or cause health effects. Evidence of fire-related emissions is limited to observations of soot, ash and char particles on certain interior surfaces and in air samples. While even much this evidence is flawed or misinterpreted (Section 5.2), the levels of combustion residues are far below levels needed to produce any meaningful risk of a health effect. Thus, no evidence exists to support the conjecture pertaining to off-gassing or harmful levels of PAHs or other carcinogens due to fire-related combustion residues at the Metropolitan.[68]

FBS statements pertaining to the health risk of cancer from fire combustion residues represent phantom risks. The presence or suspicion of a carcinogen does not mean that an actual or imminent risk is present and unacceptable, and that mitigation, removal, building renovation or reconstruction is required. If so, modern

65 Based on BaP's atmospheric hydroxylation rate (7.8E-11 cm^3/molecules-s) and typical urban OH concentrations (6E6 molecules/cm^3), most BaP will be degraded in 0.4 hours; considering lower and average tropospheric levels of OH (1.1 E5 cm^3/molecules-s), degradation will take 2.3 hours. Environmental properties from ToxCast, https://www.epa.gov/chemical-research/toxcast-chemicals

66 AIHA 2018, ibid.

67 Kohl, L. et al. Limited Retention of Wildfire-Derived PAHs and Trace Elements in Indoor Environments, *Geophysical Research Letters*, 46, 383-391.

68 See footnote 41

commerce and countless human activities that use many of the tens of thousands of chemicals in commerce would cease in their present form.

7.7 Summary of health risks

There is no evidence that fire-related combustion residues at the Metropolitan would cause adverse effects, including chemicals that may migrate from residues settled or deposited in building cavities into occupied spaces. Screening level calculations and recent literature show that health risks are extremely unlikely and that indoor levels of many chemicals will decline over time. Even if significant smoke exposure had occurred, the use of appropriate cleaning and restoration practices would return the building to normal and safe conditions.

The evidence at the Metropolitan strongly suggests that common everyday sources of PAHs and other SVOCs, e.g., industrial and traffic-related pollutants, candles, cigarette smoke, cooking, gas combustion, etc., would far exceed levels that could be produced by off-gassing and/or migration of any combustion residues that might be present.

FBS did not obtain quantitative measurements of carcinogens or other toxic substances in their sampling. FBS did not conduct a quantitative risk assessment or use other objective method to assess possible health risks from fire residues at the Metropolitan. FBS expressed numerous statements that can be characterized as *phantom risks*, scientifically known as a false positive or type 1 error, that misrepresented risks.[69]

8 Cleaning and restoration

Post-fire cleaning and restoration guidance is well developed.[70] Practices include the use of dry or wet removal techniques, e.g., mopping, damp wiping, pressure washing, air scrubbing, and vacuuming using HEPA-filter equipment; removal and replacement of air filters; and immersion cleaning of absorbent materials, etc. Inspections and tests could be used to verify the effectiveness of cleaning/restoration, including showing negligible levels of hazardous chemicals. Standard cleaning and restoration practices at the Metropolitan would be expected to remove fire-related combustion residues and return conditions to normal levels that do not pose a health risk.

9 Conclusions

There is no evidence supporting significant infiltration, penetration or migration of smoke and combustion residues from the Phase 6 building fire into Phase 1-3 buildings, rather, the prevailing meteorology, building configurations, and other factors would limit smoke exposure and infiltration and particle penetration through the building envelope. Some samples in some areas of Phase 4 and 5 buildings had greater potential of smoke exposure from the fire, but the sampling data shows only limited areas with a high likelihood of combustion

[69] This is arguably the most basic type of statistical error. In elementary statistics, students learn to avoid these errors in hypothesis testing using the concept of a p-value.

[70] For example, see the following:

US EPA, Should You Have the Air Ducts in Your Home Cleaned? https://www.epa.gov/indoor-air-quality-iaq/should-you-have-air-ducts-your-home-cleaned

Institute of Inspection, Cleaning and Restoration Certification Standard

Restoration Industry Association, Guidelines for Fire and Smoke Damage Repair, 2nd edition. Washington, D.C. 2007.

National Air Duct Cleaners Association, Standard for Assessment, Cleaning, and Restoration, 2013.

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residues, the pathway for entry of fire-related combustion residues was not completed, and thus the penetration and entry of fire-related combustion residues into the building is low or minimal. This is supported by the reanalysis of the FBS sampling data that showed normal levels of fire-related combustion residues in the vast majority of samples. Only a few areas had measurements that were considered to have a high likelihood of being fire-related combustion residues.

There is no evidence supporting that adverse health effects could be caused by combustion residues present in the Metropolitan. While soot, char and ash can contain chemicals that are considered carcinogenic, these compounds were not quantified; the evidence shows few locations where fire-related soot, char or ash was identified at high levels with high likelihood; the same applies for combustion residues in building cavities levels that also have low potential migration and human exposure. Conclusions drawn by FBS regarding widespread and serious contamination by fire-related combustion residues that will cause cancer are unfounded by the evidence and lack the essential foundations of exposure, dose, pathway, reference level, and risk quantitation to be scientifically credible.

The amount of PAHs in building cavities that is needed to present even a small health risk would exceed any level reported or inferred at the Metropolitan by orders of magnitude. Even where combustion residues are present, the governing physical/chemical mechanisms and recent literature indicate that the level of combustion residues will diminish over time and not pose meaningful risks of adverse health effects. Any off gassing of fire-related residues would decrease over time, and normal ventilation and air change in the Metropolitan would flush out and degrade any emissions that made it to occupied spaces.

Cleaning and restoration of smoke exposed portions of the building would have been sufficient to return the building to normal and safe conditions.

The testing data by FBS pertaining to fire-related combustion residues and other evidence discussed above provide no rationale for the full remediation the Phase 1-5 buildings.

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